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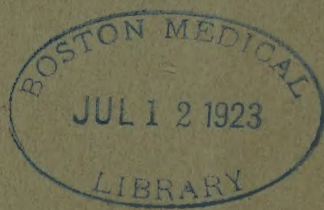
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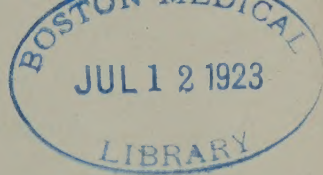
A STUDY OF
CERTAIN SHADES AND GLOBES
FOR ELECTRIC LIGHTS,
AS USED IN
/ INTERIOR ILLUMINATION /

BY
WILLIAM LINCOLN SMITH, S.B.

PART I

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*A STUDY OF CERTAIN SHADES AND GLOBES FOR
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MINATION.*

BY WILLIAM LINCOLN SMITH, S.B.

PART I.

Received July 12, 1900.

A. PRELIMINARY REMARKS.

Two features which, perhaps more than all others, serve to distinguish our modern artificial sources of illumination from those of older date, are, first, the smallness of the flame or light-giving body, and, second, the high intrinsic brilliancy of the same.

The Welsbach incandescent mantle and the Acetylene flame are examples of gas-using apparatus, and the electric arc and incandescent filament of apparatus perhaps more widely used.

On account of these distinguishing features of modern lights, it becomes imperative to use in connection with them, for purposes of general illumination (omitting, of course, such special purposes as lighthouse work, various kinds of signal lights, and in general, all cases where a concentrated, brilliant ray is desired), some form of shade or enclosing globe which shall cut down the intrinsic brilliancy, and, if possible, concentrate the softened light in those directions or upon those objects where illumination is particularly desired.

While there are many interesting and important points to be considered in connection with the problem of satisfactory illumination of interiors, it is not proposed to do more than touch briefly upon them here, the reader being referred to the various published works upon the subject, and to a series of articles begun about the first of May, 1900, by Dr. Louis Bell, in the *Electrical World*, published in New York.

We should aim emphatically to avoid the production of alternate spots of light and darkness, such as are frequently noticed when a

naked arc is used over a street well shaded with trees, since the strain put upon the eye by constant endeavor to adjust for the varying conditions is very severe. On the other hand, we must sedulously avoid the production of absolutely *uniform* illumination and the consequent total suppression of all shadows, as in this case the eye will be deprived of its principal guide to the judging of distances and proportions of objects with a resulting strain fully as severe as that resulting from the other extreme. We get an illustration of this on those happily rare occasions when the sun is high in the heavens but the sky is veiled by a very thin white cloud, which, although not sufficient to materially diminish the brilliancy of the light, yet causes absolute diffusion and the obliteration of all shadow. The light enters the eye in unwonted quantity from unwonted directions, and the exhausting nature of the effect produced is well known.

It is a fortunate fact for us in our attempts to produce satisfactory illuminations, that the eye does not depend upon the *absolute* illumination of bodies; but that the absolute illumination of a landscape or room may vary within very wide limits, and, provided the *relative* illumination of the several parts remains unchanged, the eye will still be satisfied.

Again, it is a fact, though apparently unknown to many, that for the majority of purposes, a well distributed *moderate* illumination is far superior for results obtained, and comfort and ease of the eye, than a decidedly brighter and more concentrated illumination. The reason is, that in the first case the eye is able to work with a larger aperture and the muscles in a more easy state, while in the second case the aperture is stopped far down and the muscles more tense and strained.

Nevertheless, the average person is more prone to transgress rules of health and comfort in the matter of illumination than in many another less important matter. As a salesman of a large supply house said to me some time since in regard to a certain shade, "We know perfectly well that that is one of the best and most satisfactory patterns we handle, but you can't make the average buyer believe it."

The average person is not satisfied with a good, soft, well-distributed illumination; he wants something with more size to it, a big glare for his money. He would never dream of allowing direct sunlight to fall upon his desk, but he will deliberately hang a good-sized incandescent light over his work, about a foot in front of him

and a foot above his head, so that every time he raises his eyes they meet that bright spot.

Again, he will work, or be made to work, at a desk thus lighted by a single lamp, a green paper or tin shade put upon it to concentrate the light downward, and the rest of the room in consequent gloom, so that every time he looks away from his work the eye passes from light to shade, and back again, with the resulting strain upon it, so that after a little while another person has to be fitted with glasses.

The remedy is, of course, simple, and there exists no excuse for neglecting it. If a bright light is needed localized upon a desk or table, this should be superposed upon a moderate general illumination of the room, so that the decided contrast of light and shade is prevented. Or, if only the single desk light is to be burned, it should be fitted with some type of shade which, while projecting the greater part of the light downward upon the work, will still allow a sufficient amount to escape to produce a mild illumination of the surroundings. In any case, the light should be so placed as to be out of the field of view of the worker under all ordinary conditions.

Some years ago, before the introduction of modern high power sources of light, the position and arrangement of artificial lights according to each person's pleasure or whim made little difference. Fixtures and lamps could be arranged any way (subject only to the requirements of combustion); they could be used by the architect or decorator to "dress up the walls," and for other purposes wholly aside from their sole reason for being — *i. e.*, supply of artificial illumination — or, as was still more often the case, they could be put wherever the gasfitter found it most convenient to punch a hole in the wall. The introduction of electric lighting made the state of affairs still worse, because these lamps could be put upside down, or any other way, at will.

It is hardly too much to say that the ordinary person does not know enough to properly arrange his own lights — the average wireman certainly does not — and that the architect and interior decorator too frequently will not, because he still is carried away with the desire to use fixtures and lights for decorative purposes, more or less in defiance of scientific considerations. This use for decoration of interiors is legitimate certainly, provided it is not allowed to mask the true purpose of the sources of light, so as to make them rather sources of torment than of light to the unfortunates who may be forced to sit

near them, and who have mind and soul distracted from their proper occupations for the time being, in the vain attempt to avoid dazzle or glare and allow the eyes to take in surrounding objects in peace and comfort.

As a matter of fact, the source of light ought to be invisible, or else so toned down as to be unobtrusive, and its presence simply inferred from the general excellence of illumination produced by it; for it is a self-evident fact that we only desire to *see the light source in the single case of signal lights, and in all other cases we desire to see an object or objects by the aid of the light-source*, for which purpose the source itself should be outside the field of view.

Since, in the vast majority of cases, it would be either exceedingly inconvenient or expensive to hide the source of light completely, it has become customary to leave it exposed (and frequently in the field of view), but to fit it with a shade of some kind, so as to render it more unobtrusive and more suitable for the purpose at hand.

Shades may be classified into :

1. Those which aim to be simply ornamental, and which being nothing else, will not be considered further.
2. Those which aim to cut down the light and diffuse it more or less.
3. Those which aim not to diffuse the light, but simply to concentrate it in certain directions.
4. Those which aim to both diffuse the light and also to distribute it in certain directions.

There is an enormously large number of shades upon the market, the vast majority of which have no other reason for being than to satisfy the whims of their makers, and the individual idiosyncrasies of the hoped-for purchaser. How whimsical they are, and how little the particular pattern of any one has to recommend it, is shown by the recognized difficulty of replacing, a year or so after purchase, any one of a set which may have become broken.

A small minority remain on the market through a number of years, because they have become, as it were, standard patterns, and are simple, such as plain, frosted, and opal globes of various tints.

A still smaller number remain because they, in a more or less satisfactory manner, do the work for which they were designed, and do it comparatively well and fairly efficiently, one, at least, remarkably efficiently.

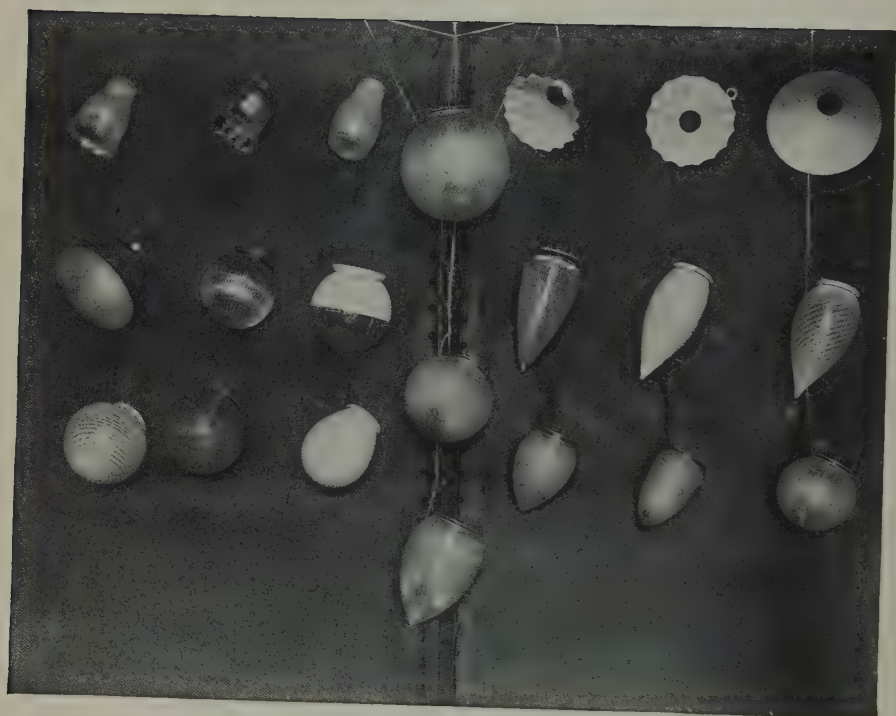


FIG. 1. — GROUP OF SHADES, UNILLUMINATED.

9	13	8	1	19	20	18
14	22	15	2	10	11	12
24	21	23	4	5	6	7

The following series of tests were made upon a number of the leading types of shades and globes for electric lights, by no means exhaustive of available styles, but still, it is believed, fairly representative, and form part of a more extended study of illumination which it is hoped to continue the present winter.

The results here given will be found to be based principally upon Mean Spherical Candle-power. I am well aware that this quantity has been made too much of in the past, and that it is not always nor most frequently the best standard of comparison, since it is not the quantity with which we are most frequently and directly concerned. I think, however, that at the present stage of the investigation, it is the best standard of comparison, and almost the only one available for the purpose in hand. At a later stage, others will present themselves and prove to be more convenient and satisfactory.

B. TYPES OF SHADES TESTED.

1. Holophane Pendant, one-piece sphere, Cat. No. 3,550.
2. Holophane Pendant, one-piece sphere, Cat. No. 3,551.
3. Holophane Stalactite, Class A, Cat. No. 3,354.
4. Holophane Stalactite, Class B, $5\frac{1}{2}'' \times 8''$, Cat. No. 3,250.
5. Holophane Stalactite, Class B, $4'' \times 6''$, Cat. No. 3,150.
6. The same style Holophane, but with old style of cutting.
7. Holophane Upright one-piece sphere, Cat. No. 3,105.
8. Holophane Pendant Tulip, $3\frac{1}{2}'' \times 5\frac{1}{4}''$, Cat. No. 2,251.
9. Holophane Pendant Tulip, $4\frac{1}{2}'' \times 5\frac{1}{4}''$, Cat. No. 2,250.
10. $9'' \times 3\frac{1}{4}''$ Stalactite Prism.
11. $9'' \times 3\frac{1}{4}''$ Canary Stalactite.
12. $9'' \times 3\frac{1}{4}''$ Opaline Stalactite.
13. "M" Prismatic Tulip.
14. $7''$ McCreary Shade.
15. $6''$ Ball Pendant, upper hemisphere opal and lower hemisphere clear glass, with a many-rayed star cut in the bottom of it.
16. A. E. G. 50 C. P. 112 v. spherical bulb coiled filament lamp. Coil of filament in centre of bulb, and basal hemisphere of bulb silvered on the outside.
17. Same lamp, with silver minor removed.
18. $8''$ Deep Tin Cone, white enamel inside.
19. $6''$ Deep Cone, fluted porcelain.

20. 6" Flat Cone, fluted porcelain.
21. 6" Ground Glass Ball.
22. 6" Prismatic Glass Ball.
23. 6" Opal Ball.
24. 6" Opaline Ball.

Figure 1 is a group of these shades unilluminated.

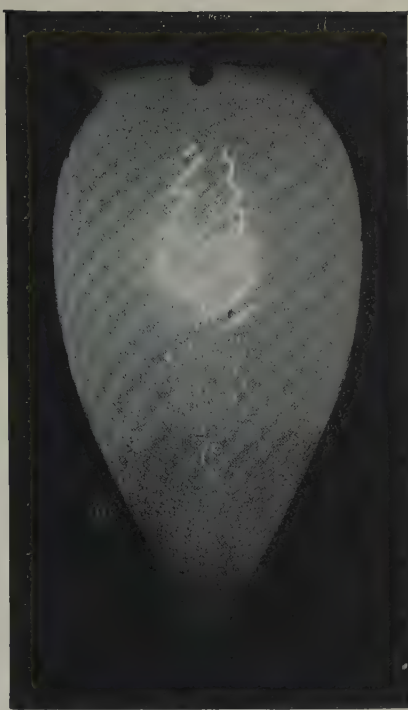
Figures 2 and 3 show the four large stalactites, namely, Numbers 4, 10, 11, and 12, of the table, as they appear when lighted from within. The effect of the shades when studied together with the distribution curves is very evident. The Canary Stalactite simply cuts the light down slightly, affecting no redistribution, and the filament remains perfectly and unpleasantly in evidence. The Opaline Stalactite does not reduce the light so much, and does not produce so unpleasant an effect, but neither does it redistribute. The effect is to produce an appearance of the filament, as though it were reflected in a rippling surface of water. The Stalactite Prism is comparatively ineffective, and there appears a double image of the filament, just distinguishable in the cut, but very prominent in the actual shade. The Holophane, however, glows all over uniformly, and there is almost complete diffusion. Moreover, there is redistribution downward, which causes the lower portion to appear darker when viewed from the angle at which the camera was placed. This shade *ought* to be fitted to a 32 C. P. light, but for purposes of comparison it was used with the same lamp as the others, none of which would admit of using larger than a 16 C. P.

The first nine shades are made of the so-called Holophane glass, which aims at both diffusion and directive action on the rays of light given off by the enclosed lamp. It accomplishes its results by two systems of cutting, one on the inner and the other on the outer surface of the shade. That on the inner is a system of ribs, running vertically, shown in cross-section (section on a horizontal plane) in Figure 4.

The outside system of cutting consists of parallel prisms, one above the other, covering the whole outer surface of the shade. Each circular prismatic ring has its angles determined by its position on the shade and the deflecting effect desired of the shade as a whole. Each prism has a compound surface, one part acting by refraction and the other by total reflection. This system of cutting is shown in Figure 5, which is a section on a vertical plane. The inside system produces



FIG. 2. — CANARY STALACTITE.



OPALINE STALACTITE.



FIG. 3. — HOLOPHANE STALACTITE, NO. 3250.



STALACTITE PRISM.

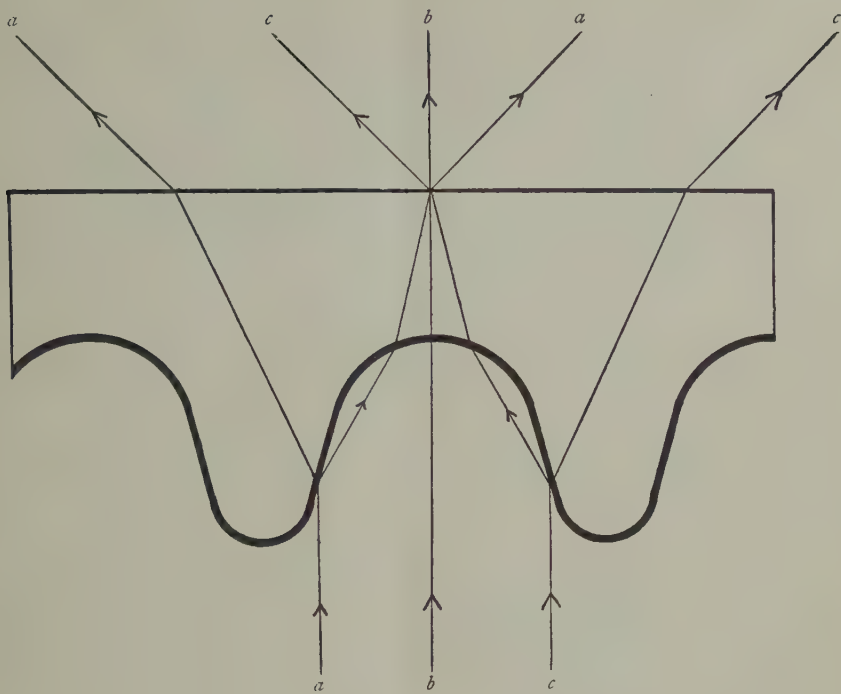


FIG. 4.

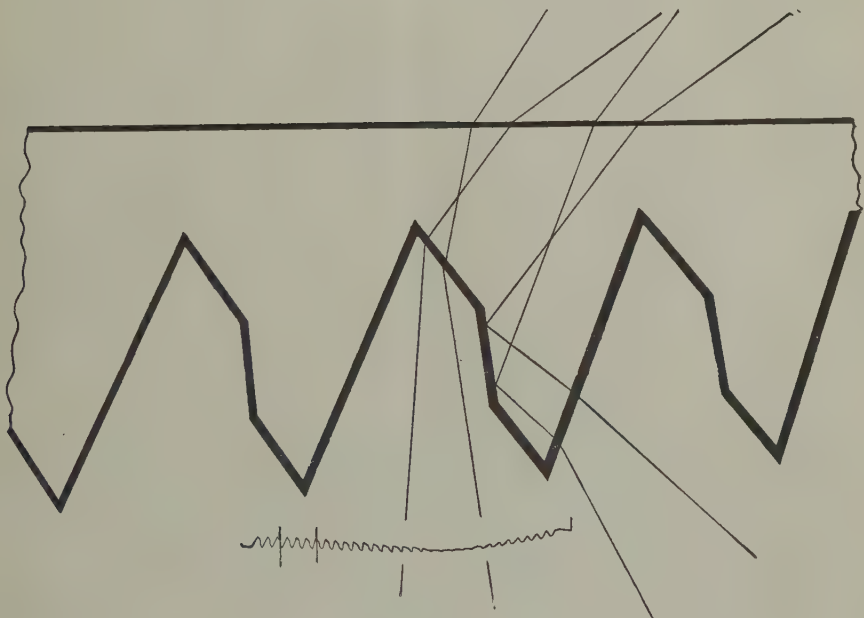


FIG. 5.

diffusion, and the outside system produces the desired deflecting of the various rays, the shade itself being made of clear glass. This type of shade is thoroughly well worked out on accurate lines, is very efficient, and produces a most pleasing illumination, soft and powerful; the source of light appears to be a large, mildly glowing surface of sparkling points, very unobtrusive, it being possible to see readily and comfortably past the light. The shade is also free from spectral bands of color, which occasionally appear with some other types.

Number 10 is a shade which might by some be mistaken for a Holophane, but its interior ribs are simply V slots, and its outer prisms totally different. It is not at all in the same class.

Numbers 11 and 12 are both very common, the first being a long, graceful stalactite of a canary-yellow color, and the second similarly shaped, of a pale blue opalescence, with spiral flutings running about it from tip to base.

Number 13 is a small, bell-shaped shade, just large enough to take an ordinary 16 candle-power lamp. The upper quarter of the shade is clear glass with slight markings on it; the central half a band with very fine V-shaped flutings running horizontally in circles about the outside, and vertically upon the inside; while the lower quarter of the shade is again clear glass.

Number 14 is a well-known type.

Number 15 is a very peculiar pattern, — a ball, with the lower half of clear glass with a large star-shaped figure cut in it, the centre of the figure being at what might be called the south pole of the ball, and producing upon the surface of table or floor below, curiously unpleasant striations of light and shade. The upper half, containing the hole and flange for holding the lamp and socket, is a thick, milk-white opal.

The remainder of the shades are all common types, and require no description.

C. METHOD OF TESTING.

Three lamps were chosen, all general electric, rated at 112 volts, and respectively 16, 32, and 50 candle-power. These lamps were carefully tested unshaded, and then fitted with the various shades as desired. Four of the shades, however, as noted further on, were tested upon a Bryan and Marsh lamp, as the 16 C. P. G. E. was unfortunately broken. Measurements were made upon a 200-inch

photometer bar very thoroughly screened, and all stray light was thus eliminated. Of course, we must realize that when the shaded lamps are upon the photometer the source of light is no longer a point, or even approximately one, and hence the law of inverse squares is no longer strictly true.

The plan of wiring of the apparatus is shown in Figure 6, and is evident from the drawing. The circuit passed from the main switch

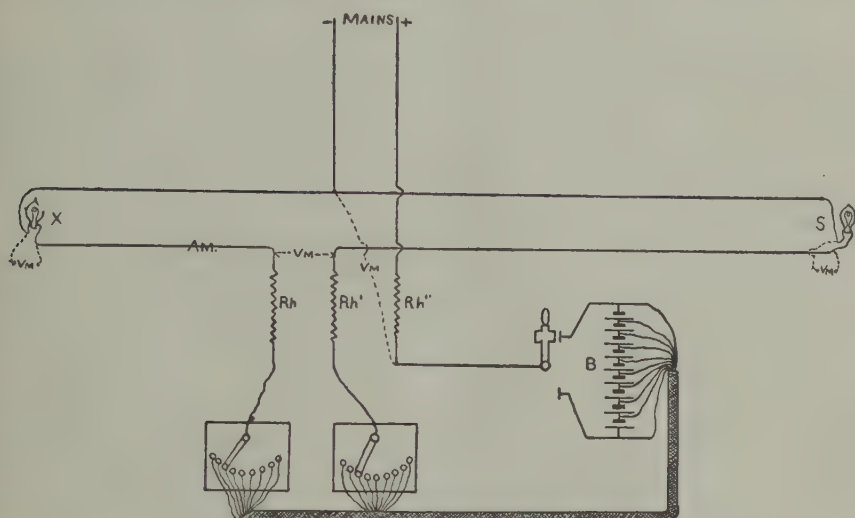


FIG. 6.

through a variable carbon resistance, Rh'' , to one end of a storage battery B , arranged for either positive or negative boost, and from the battery through a pair of selecting switches to two more carbon resistances, Rh and Rh' , the circuit from one of these going to one end of the bar, the circuit from the other, to the opposite end. At the right-hand end of the bar was the holder for the incandescent lamp, serving as the secondary standard, and at the left end of the bar two separate holders, one controlled by hand for setting the lamp under test at any desired angle of latitude and longitude, the other rotated by a motor for the making of spinning measurements. Loops were left for the insertion of ammeters, and voltmeter leads were brought from the *lamp terminals*, the mains, and the differential point between the two lamps. All wiring was done with No. 00 wire between the lamps, so that the drop, except in the carbon resistances, was negligibly small,

and would still remain so when the circuits were carrying current for good-sized series lamps.

Suppose, then, that it was desired to test a 120-volt lamp using a 104-volt standard. We would connect the 110-volt mains to the apparatus, and by means of the selector switches and storage battery, bring the pressure at the terminals of the 120-volt lamp to approximately that amount. Then, by means of the carbon resistances in series with the two lamps, adjust the pressure of one to exactly 120, and of the other to exactly 104.

The voltmeter could now be put across the mains, and if the pressure rose or fell above 110, thus raising or lowering the pressure at the two lamps proportionately, it could be brought back, if desired, by the carbon resistance, Rh'' , first mentioned as inserted in the main before it reached the point of branching to the two lamps.

It is, however, unnecessary that this pressure at the mains should remain absolutely fixed, since it is well known that so long as the two lamps remain at the proper *relative* pressures, the *absolute* pressure may vary within moderate limits without affecting the ratio of the two lights, provided the lamps are of approximately the same efficiency. The correctness of the relative pressures could be checked at any time by simply putting the voltmeter across the differential points between the two lamps, when it should measure (in this supposed case) $120 - 104 = 16$ volts, and in case it did not, the lamp which had changed could be detected and the change corrected.

The lamp to be tested was then placed in the hand-controlled holder, and the candle-power measured for every 30 degrees around the equator of the lamp. The candle-power was then measured for every 30 degrees on four meridians of the lamp, namely, those on longitude 0° , 45° , 90° , and 135° , thus allowing of the plotting of curves of horizontal distribution and four equally spaced curves of vertical distributions. These curves give to the eye a very good idea of the distribution of light from the lamp. It would be simple to calculate from them the quantity called the Mean Spherical Candle-power, which is used in comparing the various tests, and which may be defined as the "sum of the illuminations received by a sphere of radius unity concentric with the light-source, divided by the surface of this sphere." I preferred to determine it, however, by a separate test, as follows: The lamp was placed in the spinning apparatus, and readings taken every 15 degrees from tip to base, thus giving thirteen

equally spaced readings of mean candle-power at the several angles, and enabling a curve of distribution to be plotted, as in Figure 7, which is the curve for the Canary Stalactite. If, then, we measure the area of the right-hand curve of Figure 7, and also that of the enclosing rectangle; take the ratio of these and multiply the maximum ordinate by this ratio; the result will be the Mean Spherical Candle-power desired.¹

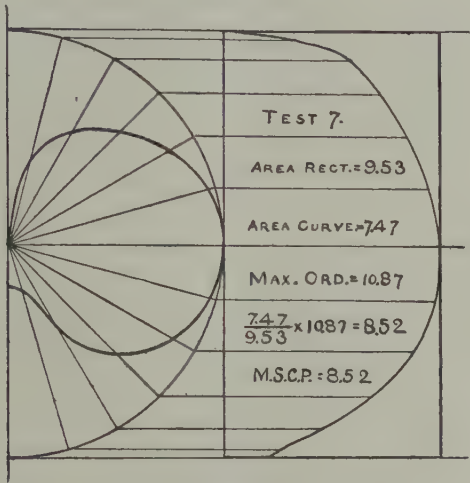


FIG. 7.

D. STANDARDS OF LIGHT USED.

The primary standard used was a Hefner-Alteneck lamp, burning acetate of amyl, made by Krüss, numbered 796, and bearing the Reichsanstalt certificate No. 430. This is usually assumed to be equivalent, under proper working conditions, to .885 standard candles. I compared it against twelve standard candles, using a 100-inch bar and a Lummer Brodhun screen, and obtained a mean value of .869 candles.

The secondary standard which was used throughout the tests was a special aged incandescent lamp run at 112 volts, and giving in the marked direction, as compared with the Hefner lamp, a value of 10.57 candle-power, this value being the mean of twelve tests.

¹ Palaz, A. Treatise on Industrial Photometry. Trans. by Patterson. Ed. 2. New York, 1896.

These tests were made at about equal intervals throughout the course of the work and the mean value used in the calculations.

Voltage was measured on a Weston voltmeter, No. 4,915, which has been carefully kept and calibrated frequently; its error at 112 volts (the voltage used in all this work) was $+ 0.14$ volts.

Current was measured on two Weston ammeters, No. 1,856, reading to 1.0 ampere and with negligible error, the other, No. 384, reading to 5.0 amperes and having a zero error of $+ .05$ ampere.

In the calibration of the secondary standard a Lummer-Brodhun screen was used, but throughout the rest of the work a Bunsen disc, which had in previous work proved very satisfactory, was made use of, as it was far more convenient and satisfactory for my purpose.

E. SAMPLE OF TESTS.

The following six tables form the complete record of readings taken for one test, namely, the first made upon the Canary Stalactite, the plot of mean spherical candle-power for which (the data for this plot being found in table 7*f* following) has already been referred to in Figure 7. Three tests, similar to the one given here, were made upon each shade, and the final results given are invariably the mean of these three, except in the one case of the A. E. G. spherical bulb lamp, where the silver minor was taken off before I had an opportunity to make check tests. In this case, also, the tests given were made as part of the regular laboratory work by two students, who were, however, very careful workers. The test on this lamp made after removal of the silver I was able to check, and found no serious discrepancies. All the other tests here recorded were made by myself, although in several cases the lamp or shade was further tested by students, and checking results obtained; these, however, are not given.

PHOTOMETRIC TEST No. 7a.

Date of test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3 $\frac{1}{4}$ ", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4,915, error = + 0.14. Weston Ammeter, No. 1,856; error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796; Certificate No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

DISTRIBUTION IN HORIZONTAL PLANE THROUGH EQUATOR.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.	Volts.	Amperes.
	1.	2.	3.	4.				
0°	1.030	1.025	1.035	1.030	1.030	10.9	112.0	.496
30°	1.025	1.030	1.030	1.040	1.032	10.9	112.0	.496
60°	1.035	1.024	1.030	1.030	1.030	10.9	112.0	.496
90°	1.035	1.035	1.025	1.040	1.034	10.9	112.0	.497
120°	1.030	1.035	1.030	1.035	1.033	10.9	112.0	.495
150°	1.025	1.020	1.025	1.035	1.026	10.8	112.0	.496
180°	1.035	1.030	1.025	1.040	1.034	10.9	112.0	.495
210°	1.028	1.035	1.035	1.038	1.034	10.9	112.0	.496
240°	1.032	1.035	1.038	1.037	1.035	10.9	112.0	.496
270°	1.024	1.028	1.030	1.028	1.027	10.8	112.0	.497
300°	1.025	1.030	1.031	1.028	1.028	10.9	112.0	.496
330°	1.020	1.025	1.030	1.035	1.028	10.9	112.0	.496
0°	1.025	1.031	1.034	1.029	1.031	10.9	112.0	.496

PHOTOMETRIC TEST No. 7b.

Date of test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3½", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4915, error = + 0.14. Weston Ammeter, No. 1,856; error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796, Certificate No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

DISTRIBUTION IN VERTICAL PLANE THROUGH 0° LONG.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.	Volts.	Amperes.
	1.	2.	3.	4.				
0°	1.027	1.029	1.035	1.030	1.030	10.89	112.0	.496
30°	.905	.904	.901	.907	.904	9.56	112.0	.497
60°	.440	.435	.440	.435	.437	4.62	112.0	.497
90°	.206	.207	.208	.205	.207	2.19	112.0	.496
120°	.445	.450	.445	.440	.445	4.71	112.0	.496
150°	.910	.905	.907	.905	.907	9.59	112.0	.495
180°	1.025	1.030	1.035	1.031	1.031	10.90	112.0	.496
210°	.900	.904	.902	.900	.902	9.54	112.0	.495
240°	.665	.672	.675	.678	.675	7.14	112.0	.496
270°	....	....	....	....	....	....	....	....
300°	.665	.670	.666	.665	.667	7.04	112.0	.496
330°	.895	.890	.898	.895	.896	9.47	112.0	.496
0°	1.035	1.030	1.027	1.027	1.031	10.90	112.0	.496

PHOTOMETRIC TEST No. 7c.

Date of test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3½", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4,915, error = + 0.14. Weston Ammeter, No. 1,856, error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796, Certificate No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

DISTRIBUTION IN VERTICAL PLANE THROUGH 45° LONG.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.	Volts.	Amperes.
	1.	2.	3.	4.				
0°	1.035	1.030	1.030	1.025	1.030	10.89	112.0	.496
30°	.906	.904	.900	.908	.905	9.57	112.0	.496
60°	.460	.465	.470	.465	.465	4.92	112.0	.496
90°	.208	.207	.206	.207	.207	2.19	112.0	.497
120°	.465	.467	.463	.465	.465	4.92	112.0	.497
150°	.905	.910	.904	.906	.906	9.58	112.0	.496
180°	1.030	1.035	1.035	1.030	1.032	10.91	112.0	.495
210°	.880	.884	.885	.884	.883	9.34	112.0	.496
240°	.600	.605	.605	.605	.604	6.39	112.0	.496
270°	....	....	....	....	....	....	....	....
300°	.600	.605	.610	.611	.607	6.42	112.0	.494
330°	.885	.889	.892	.884	.887	9.38	112.0	.497
0°	1.035	1.031	1.030	1.029	1.031	10.90	112.0	.496

PHOTOMETRIC TEST No. 7*d*.

Date of test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3½", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4,915, error = + 0.14. Weston Ammeter, No. 1,856, error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796, Certificate No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

DISTRIBUTION IN VERTICAL PLANE THROUGH 90° LONG.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.	Volts.	Amperes.
	1.	2.	3.	4.				
0°	1.035	1.037	1.035	1.030	1.034	10.94	112.0	.496
30°	.905	.908	.908	.905	.906	9.58	112.0	.497
60°	.485	.495	.495	.498	.493	5.22	112.0	.496
90°	.208	.207	.206	.207	.207	2.19	112.0	.496
120°	.475	.480	.475	.485	.479	5.06	112.0	.495
150°	.905	.900	.905	.899	.902	9.54	112.0	.495
180°	1.025	1.025	1.024	1.026	1.025	10.84	112.0	.496
210°	.865	.875	.875	.875	.873	9.23	112.0	.496
240°	.531	.530	.532	.526	.529	5.59	112.0	.495
270°	....	....	....	....	....	....	....	....
300°	.525	.530	.525	.529	.527	5.57	112.0	.496
330°	.875	.880	.880	.878	.878	9.28	112.0	.497
0°	1.030	1.035	1.035	1.034	1.033	10.92	112.0	.497

PHOTOMETRIC TEST No. 76.

Date of test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3 1/4", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4,915, error = + 0.14. Weston Ammeter, No. 1,856, error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796, Certificate No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

DISTRIBUTION IN VERTICAL PLANE THROUGH 135° LONG.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.	Volts.	Amperes.
	1.	2.	3.	4.				
0°	1.024	1.026	1.025	1.030	1.026	10.85	112.0	.495
30°	.907	.905	.910	.907	.907	9.59	112.0	.495
60°	.465	.465	.470	.462	.466	4.93	112.0	.497
90°	.206	.207	.208	.207	.207	2.19	112.0	.496
120°	.464	.461	.462	.458	.461	4.87	112.0	.496
150°	.910	.911	.902	.900	.906	9.58	112.0	.497
180°	1.030	1.027	1.027	1.020	1.026	10.85	112.0	.496
210°	.885	.884	.880	.879	.882	9.33	112.0	.497
240°	.610	.605	.610	.608	.608	6.43	112.0	.496
270°	....	....	....	....	....	....	....	....
300°	.607	.605	.605	.610	.607	6.42	112.0	.495
330°	.882	.880	.879	.886	.802	8.48	112.0	.496
0°	1.030	1.027	1.027	1.025	1.027	10.86	112.0	.496

PHOTOMETRIC TEST NO. 7f.

Date of Test, May 23, 1900.

Type of lamp, G. E., 112 v. 16 C. P. (marked Test lamp No. 2, 1900 W. L. S.).

Type of shade, 9" x 3½", Canary Stalactite.

Instruments used, Weston Voltmeter, No. 4,915, error = + 0.14. Weston Ammeter, No. 1,856, error negligible. Bunsen Disc A.

Standards of light used: Primary, Hefner Lamp, No. 796, Certificate, No. 430. Secondary, Aged Incandescent Lamp, calibrated as 10.57 candle-power.

MEAN VERTICAL DISTRIBUTION.

Angles.	OBSERVED RATIOS.				Mean ratio.	Candle power.
	1.	2.	3.	4.		
0°	.207	.207	.207	.207	.207	2.19
15°	.235	.236	.236	.236	.236	2.50
30°	.463	.462	.464	.463	.463	4.90
45°	.732	.730	.733	.733	.732	7.75
60°	.905	.906	.906	.906	.906	9.59
75°	.998	1.000	.999	.995	.998	10.55
90°	1.027	1.027	1.030	1.028	1.028	10.87
105°	.993	.993	.993	.993	.993	10.50
120°	.874	.875	.874	.873	.874	9.25
135°	.752	.753	.752	.753	.752	7.95
150°	.600	.601	.600	.603	.601	6.36
165°	.426	.426	.426	.423	.425	4.50
180°	....	....	....	....	....	0.0

This table is for plot used in determining the Mean Spherical Candle-power. 0° means the tip of the shade, and 180° means the base. The resulting curve is that previously given in Figure 7.

F. RESULTS OF TESTS.

The following table gives the results obtained from the different shades, and is self-explanatory. The numbers in the upper row refer to the number of the shade in the list previously given, — those in the bottom row to the plate on which the distribution plots will be found. The standard position of the lamp was with the plane of the shanks of the filament at right angles to the photometer bar, the side of the

NUMBER OF SHADE.	A.	B.	C.	D.													
	G.E., ₁₆ C.P. Test lamp.	G.E., ₅₀ C.P. Test lamp.	G.E., ₃₂ C.P. Test lamp.	B.M., ₁₆ C.P. Test lamp.	2.	3.	10.	13.	14.	11.	4.	4A.	15.				
Mean Spherical candle-power	11.28	31.00	21.90	13.50	26.70	18.70	7.81	10.07	7.50	8.52	9.45	27.90	8.63				
Mean Horizontal candle-power	14.07	37.20	27.30	16.80	30.60	16.10	9.65	10.39	2.29	10.90	8.51	34.70	3.20				
Mean Standard reading	13.34	36.10	27.10	16.83	30.70	16.00	9.76	11.40	2.29	10.90	8.51	35.00	3.23				
Spherical ÷ Standard	.846	.860	.868	.802	.848	1.17	.800	.884	3.28	.782	1.11	.796	2.67				
Horizontal ÷ Standard	1.05	1.03	1.01	.998	.998	1.01	.989	.912	1.00	1.00	1.00	.992	.992				
Spherical ÷ Horizontal	.803	.834	.803	.804	.850	1.16	.809	.969	3.28	.782	1.11	.805	2.69				
Per cent. of absorption . . . . .	....	....	....	....	13.8	14.6	30.8	10.1	33.5	24.4	16.2	10.0	23.5				
Per cent. of light thrown below equator	50.9	50.2	50.4	50.4	55.8	63.2	53.4	56.9	90.9	49.4	54.2	62.6	73.0				
Per cent. of light thrown above equator	49.1	49.8	49.6	49.6	44.2	36.8	46.6	43.1	9.1	50.6	45.8	37.4	27.0				
Maximum candle-power . . . . .	....	....	....	....	31.50	34.97	9.82	15.22	42.72	10.90	11.47	38.10	17.98				
Angle of Maximum candle-power	0°	0°	0°	0°	-15°	-90°	0°	-60°	-90°	0°	-45°	-35°	-90°				
Volts on lamp	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0				
Amperes in lamp	.496	1.51	.996	.501	1.51	.995	.495	.495	.496	.496	.496	1.51	.496				
Watts in lamp	55.6	169.	111.6	56.1	169.	111.5	55.4	55.4	55.6	55.6	55.6	169.	55.6				
Watts per Mean Spherical candle-power, ...	4.92	5.46	5.10	4.15	6.33	5.96	7.10	5.50	7.41	6.52	5.88	6.06	6.44				
Watts per Mean Horizontal candle-power	3.94	4.55	4.09	3.34	5.52	6.93	5.75	5.29	24.3	5.10	6.54	4.87	17.4				
Watts per Maximum candle-power . . . . .	....	....	....	....	5.37	3.19	5.64	3.64	1.30	5.10	4.85	4.44	3.09				
Compare with test lamp . . . . .	....	....	....	....	B.	C.	A.	A.	A.	A.	A.	B.	A.				
Plot on plate number	1	....	....	....	2	3	4	5	6	7	8	9	10				

NUMBER OF SHADE.		6.	5.	16.	17.	7.	8.	9.	19.	18.	20.	21.	22.	23.	24.
Mean Spherical candle-power		9.39	10.06	19.10	24.60	9.92	10.14	10.07	9.89	8.12	9.84	10.20	10.73	9.15	10.38
Mean Horizontal candle-power		12.00	11.40	7.85	28.90	10.48	12.32	12.00	5.26	0.0	13.94	13.08	15.65	10.05	12.50
Mean Standard reading		11.88	10.94	9.90	30.35	10.46	12.30	11.99	5.34	0.0	13.96	12.32	15.25	10.05	13.20
Spherical $\div$ Standard		.790	.920	1.93	.811	.948	.825	.841	1.85	....	.704	.790	.704	.912	.787
Horizontal $\div$ Standard		1.01	1.04	.793	.952	1.00	1.00	1.00	.985	....	.999	1.01	1.03	1.00	.948
Spherical $\div$ Horizontal		.782	.884	2.43	.852	.946	.824	.840	1.88	....	.706	.780	.686	.912	.831
Per cent. of absorption		16.8	10.8	22.3	....	12.1	10.1	10.8	12.4	28.1	12.8	24.4	20.7	32.2	23.0
Per cent. of light thrown below equator		60.2	61.8	100.0	53.2	57.6	59.6	59.2	69.4	100.	74.0	53.6	54.0	50.0	54.5
Per cent. of light thrown above equator		39.8	38.6	0	46.8	42.4	40.4	40.8	30.6	0.0	26.0	46.4	46.0	50.0	45.5
Maximum candle-power		12.11	12.51	74.77	28.90	13.55	12.92	13.04	18.15	29.49	15.72	13.08	15.65	10.05	12.50
Angle of Maximum candle-power		-20°	-40°	-90°	0°	-35°	-40°	-60°	-40°	-90°	-30°	0°	0°	0°	-10°
Volts on lamp		112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0
Amperes in lamp		.496	.496	1.20	1.20	.497	.497	.497	.497	.497	.497	.500	.501	.501	.502
Watts in lamp		55.6	55.6	134.4	134.4	55.7	55.7	55.7	55.7	55.7	55.7	56.0	56.1	56.1	56.2
Watts per Mean Spherical candle-power,		5.92	5.52	7.04	5.46	5.61	5.50	5.53	5.63	6.86	5.66	5.49	5.22	6.13	5.42
Watts per Mean Horizontal candle-power		4.63	4.87	17.2	4.65	5.31	4.52	4.64	10.6	....	3.99	4.28	3.57	5.58	4.50
Watts per Maximum candle-power		4.60	4.44	1.80	4.65	4.11	4.31	4.27	3.07	1.89	3.54	4.28	3.57	5.58	4.46
Compare with test lamp		A.	A.	17	16	A.	A.	A.	A.	A.	A.	D.	D.	D.	D.
Plot on plate number		11	13	12	12	14	15	16	17	18	19	20	21	22	23

lamp chosen being marked with a cross, and the "mean standard reading" is the mean of all readings made when the lamp under test occupied the above position. Accordingly, in each test, the lamp within the shade occupied the same position at each angular setting that it did in the test of the naked lamp, so that in this regard the plots are directly comparable. It was found, however, impossible to plot them all on one scale, and accordingly the value of the candle-power at the tip of lamp or shade is recorded on each plot, *i.e.*, at the 90° point, in all cases except that of No. 7 (the Upright Holophane Sphere), where the position is reversed and the tip of the lamp occurs at 270° .

The only plates to which further reference is necessary are as follows:

Plate I. This shows the curves obtained from the G. E. 112 v. 16 C. P. Test Lamp used with the majority of shades. The two tests given were made one before and the other after the work, and no change in the lamp was found. Since all the other test lamps have practically the same shaped curves, it has not been thought worth while to plot them.

Plate III contains not only the curve obtained with the 32 C. P. lamp, but also on the same scale the plots for the same shade with a 16 C. P. lamp.

Plate XII gives both curves for the A. E. G. lamp, the broken line curves being taken with the silvering in place and the solid curves with it removed. These, again, are on the same scale.

TEST	
I 27	
	NAKED
Number of Test <u>1-27</u>	
Mean Spherical Candle Power	11.28
Mean Horizontal Candle Power	14.07
Mean Standard Readings	13.34
Ratio Spherical to Standard	84.6
Ratio Horizontal to Standard	105
Ratio Spherical to Horizontal	80.3
Percent Absorption	
Foot-candle light shown below Equator	50.9
Foot-candle light shown above Equator	49.1
Angle of Maximum Candle Power	0°
Value on Lamp	112.0
Amperes in Lamp	4.98
Watts in Lamp	55.4
Watts per Mean Spherical Candle Power	4.91
Watts per Mean Horizontal Candle Power	3.94
Circle Shows Mean Spherical Candle Power	
Circle Shows Mean Horizontal Candle Power	
Lamp Used <u>GE 112 v 16 CP</u>	
Shade Used <u>NONE USED</u>	
Standard Used <u>AGED INCAND.</u>	
Date of Test <u>MAY 3, 1900 to JUNE 7, 1900</u>	
Remarks <u>This is the lamp upon which the greatest part of the shades were placed. The two data were run once before and the other after the time on the shade were made.</u>	

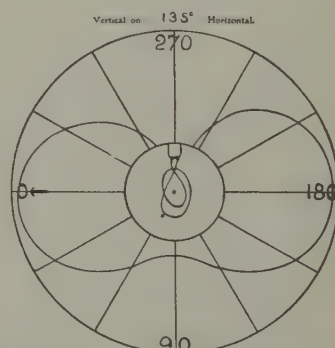
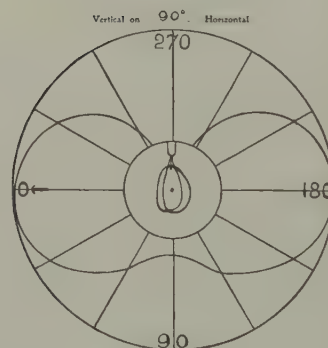
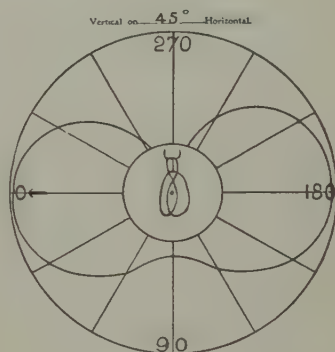
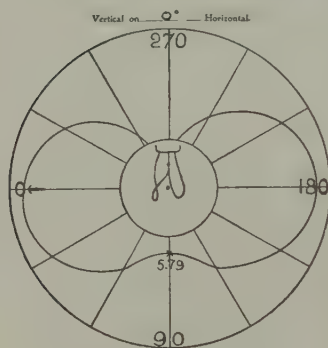
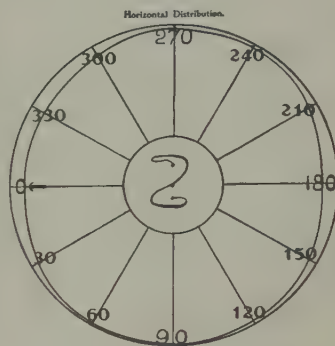


PLATE I.—CURVES FROM G. E. 112 v. 16 C. P. TEST LAMP, WITHOUT SHADE.

	LAMP	
	NAKED	SHADED
Number of Test, <u>21</u>		
Mean Spherical Candle Power	31.0	26.7
Mean Horizontal Candle Power	37.2	30.6
Mean Standard Readings	36.1	30.7
Ratio Spherical to Standard	.860	.848
Ratio Horizontal to Standard	1.03	.998
Percent Absorption	.834	.850
Percent Light thrown below Equator	50.2	53.8
Percent Light thrown above Equator	49.8	44.2
Angle of Maximum Candle Power	0°	-15°
Volts on Lamp	112.0	112.0
Amps in Lamp	1.51	1.51
Watts on Lamp	169	169
Watts per Mean Spherical Candle Power	5.46	6.33
Watts per Mean Horizontal Candle Power	4.55	5.52
Circle Shows Mean Spherical Candle Power.		
Circle Shows Mean Horizontal Candle Power.		
Lamp Used <u>C.F. 112 v. 50 CP</u>		
Shade Used <u>MOLOPHANE 33551</u>		
Standard Used <u>ASCO INCANDESCENT</u>		
Date of Test <u>MAY 18 1900</u>		
Remarks		

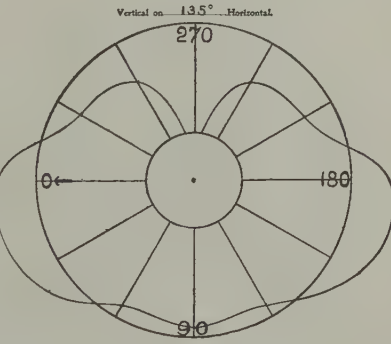
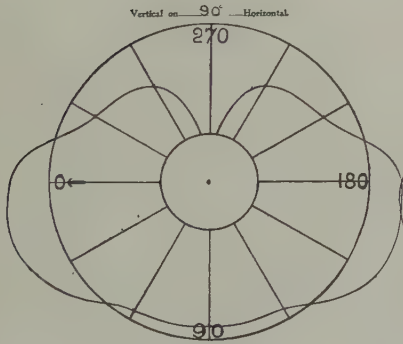
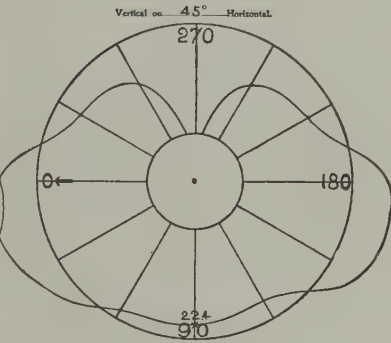
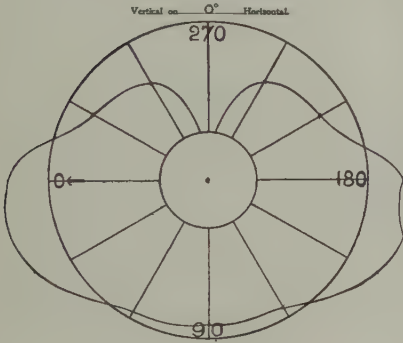
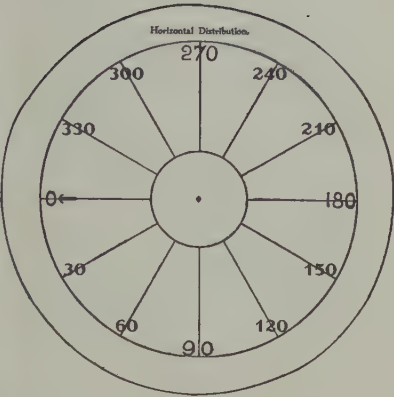


PLATE II.

	LAMP	
	NAKED	SHADED
Number of Test <u>57</u>	219	187
Mean Spherical Candle Power	273	161
Mean Horizontal Candle Power	271	160
Mean Standard Reading	808	187
Ratio Spherical to Standard	1.01	1.01
Ratio Horizontal to Standard	803	116
Percent Absorption	—	76.6
Percent Light thrown below Equator	504	61.2
Percent Light thrown above Equator	496	36.8
Angle of Maximum Candle Power	0°	-90°
Volts on Lamp	112.0	112.0
Amperes in Lamp	996	995
Watts in Lamp	1116	1115
Watts per Mean Spherical Candle Power	510	596
Watts per Mean Horizontal Candle Power	409	693
Circle Shows Mean Spherical Candle Power		
DOTTED Circle Shows Mean Horizontal Candle Power		
Lamp Used <u>GE 112V 32 CP</u>		
Shade Used <u>HOLOPHANE 3354</u>		
Installed (Yr) <u>PR. AMVL ACCT.</u>		
Date of Test <u>MAY 18, 1900</u>		
Remarks <u>The inner curves are for the same shade with a GE 112V 16 CP lamp. Mean Sph CP = 118, giving an absorption of 12.2%.</u>		

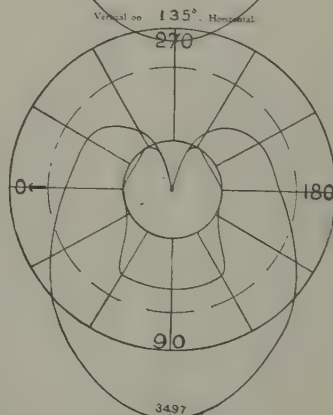
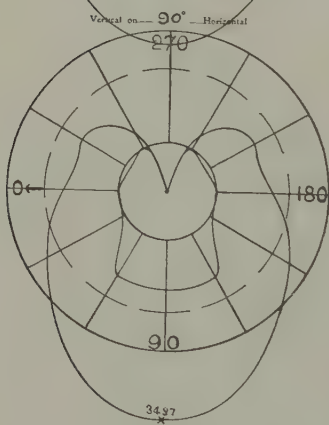
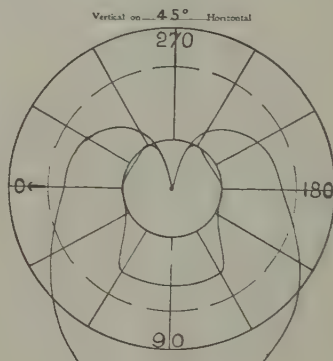
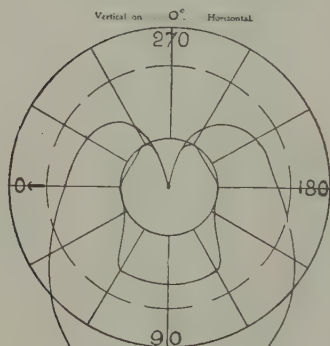
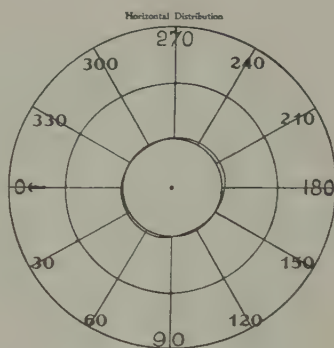


PLATE III.—SHADE, HOLOPHANE 3,354.
OUTER CURVE OBTAINED WITH 32 C. P. LAMP, INNER CURVE WITH 16 C. P. LAMP.

LAMP		
	NAVED	SHADED
Number of Taps <u>41</u>	1128	781
Mean Spherical Candle Power	14.07	9.65
Mean Horizontal Candle Power	13.34	8.76
Mean Standard Reading	84.6	80.0
Ratio Spherical to Standard	1.05	.989
Ratio Horizontal to Horizontal	80.3	80.9
Percent Absorption		30.8
Percent Light thrown below Equator	50.9	53.4
Percent Light thrown above Equator	49.1	46.6
Angle of Maximum Candle Power	0°	0°
Watts on Lamp	112.0	112.0
Amperes on Lamp	4.96	4.95
Watts per Mean Spherical Candle Power	55.6	55.4
Watts per Mean Horizontal Candle Power	4.92	7.10
Watts per Mean Spherical Candle Power	3.94	5.75
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp Used <u>GE 112 w 112P</u>		
Shade Used <u>9 3/4 STAGITE PRISM</u>		
Standard Used <u>AGED INCAND. LAMP CP-1057</u>		
Date of Test <u>MAY 21, 1900</u>		
Remarks		

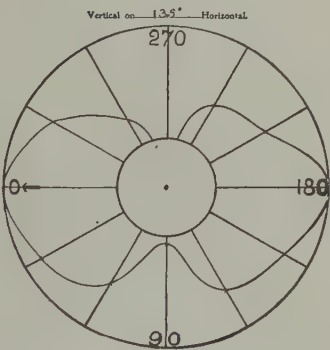
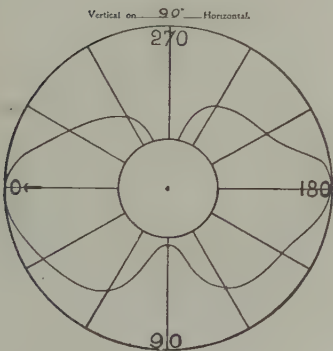
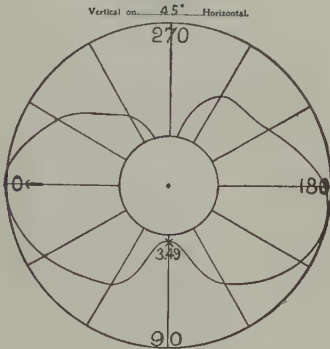
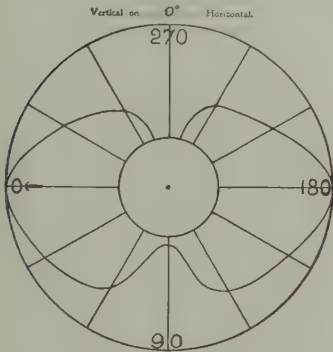
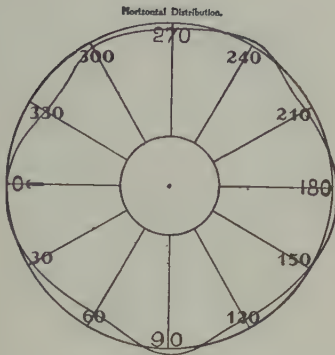


PLATE IV.

TABLE	
Number of Test	51
Mean Spherical Candle Power	112.8 10.07
Mean Horizontal Candle Power	140.7 10.39
Mean Standard Readings	133.4 11.40
Ratio Spherical to Standard	.846 .884
Ratio Horizontal to Standard	1.05 .912
Ratio Spherical to Horizontal	.803 .969
Percent Absorption	— 10.1
Percent Light Above Lamp Fixture	50.9 55.9
Percent Light Above Globe Fixture	49.1 43.1
Angle of Maximum Candle Power	9.° 80.°
Voltage on Lamp	112.0 112.0
Amperes to Lamp	.496 .495
Watts to Lamp	55.6 55.4
Watts per Mean Spherical Candle Power	4.92 5.50
Watts per Mean Horizontal Candle Power	3.94 5.29
Circle Shows Based Candle Power	
Circle Shows Mean Spherical Candle Power	
Circle Shows Mean Horizontal Candle Power	
Lamp Used	G.E. 112 v 16 CP
Shade Used	NO. PRISMATIC MCKENNEY & WATERBURY
Standard Used	A60 INCANDESCENT
Date of Test	MAY 21, 1900
Remarks	

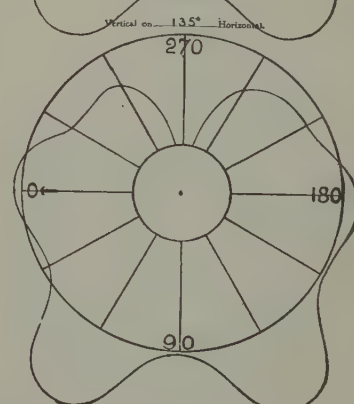
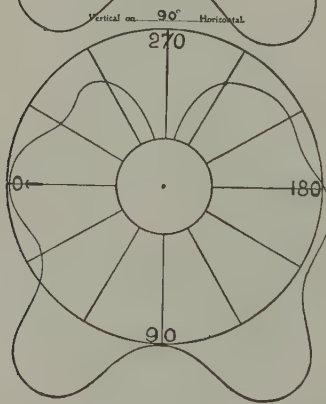
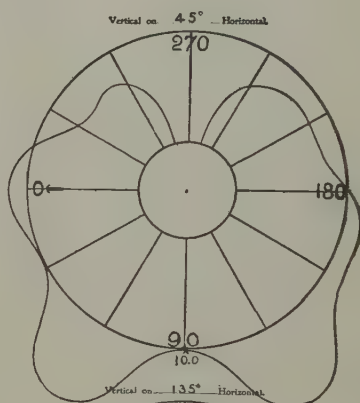
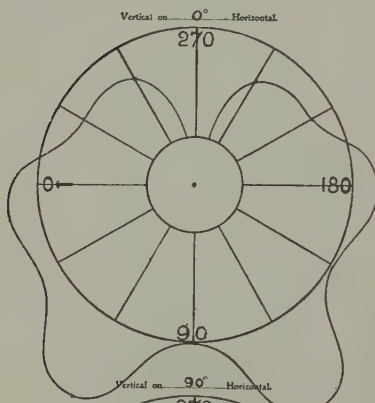
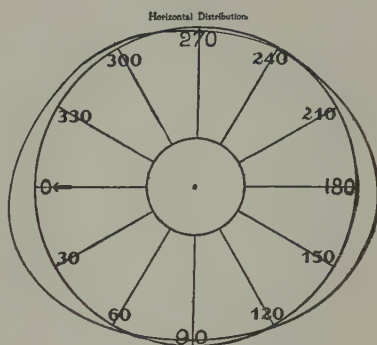


PLATE V.

LAMP		
Number of Test	61	
Mean Spherical Candle Power	11.28	7.50
Mean Horizontal Candle Power	14.07	2.29
Mean Standard Reading	13.34	2.29
Ratio Spherical to Standard	84.6	3.28
Ratio Horizontal to Standard	1.05	1.00
Ratio Spherical to Horizontal	80.3	3.28
Percent Absorption	—	83.5
Percent Light thrown below Equator	50.9	80.9
Percent Light thrown above Equator	49.1	9.1
Angle of Maximum Candle Power	0°	- 90°
Watts on Lamp	112.0	112.0
Amperes to Lamp	4.96	4.96
Watts to Lamp	55.6	55.6
Watts per Mean Spherical Candle Power	4.92	7.41
Watts per Mean Horizontal Candle Power	3.94	24.3
Circle Shows Rated Candle Power		
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp Used	G.E. 112V 16 CP.	
Shade Used	TINCL. MCCREARY	
Standard Used	AMVL ACETATE SPECIAL INGLAND	
Date of Test	MAY 22 1900	
Estimate		

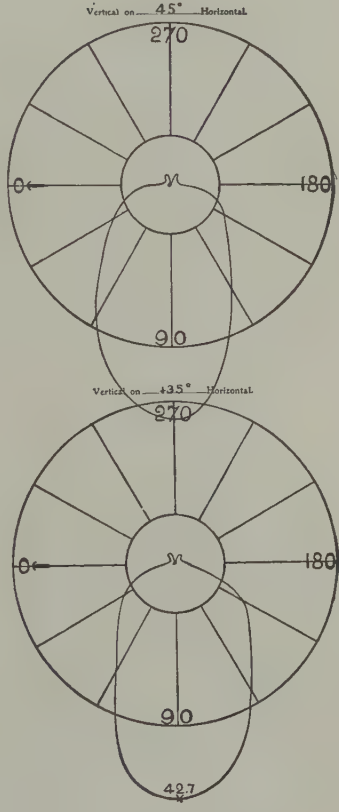
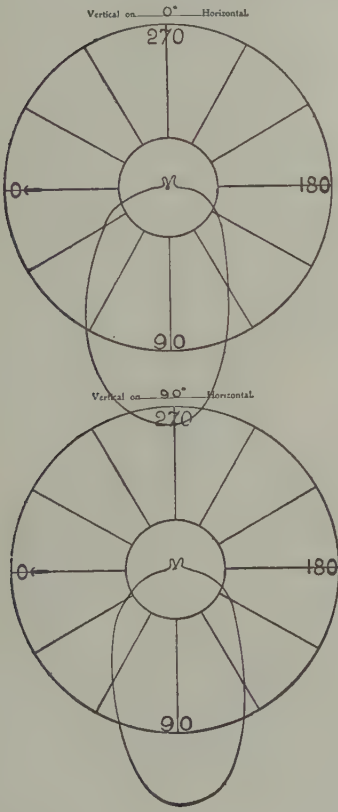
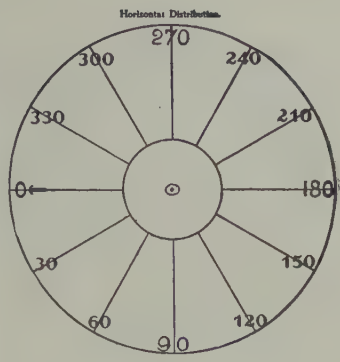


PLATE VI.

		LAMP	
		NAKED	SHADED
Number of Taps	71		
Mean Spherical Candle Power		1128	852
Mean Horizontal Candle Power		14.07	10.90
Mean Standard Reading		13.34	10.90
Ratio Spherical to Standard		.846	.782
Ratio Horizontal to Standard		1.05	1.00
Ratio Spherical to Horizontal		.803	.782
Percent Absorption			24.4
Percent Light thrown above Equator		50.9	49.4
Percent Light thrown below Equator		49.1	50.6
Angle of Maximum Candle Power		0°	0°
Value on Lamp		112.0	112.0
Answer to Lamp		.496	.496
Watts in Lamp		55.6	55.6
Watts per Mean Spherical Candle Power		4.92	6.52
Watts per Mean Horizontal Candle Power		3.94	5.10
Circle Shows Based Candle Power			
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used GE 112 V 16 CP			
Shade Used 9" x 3 1/2" CANARY STALACTITE			
Standard Used AMYL ACETATE & AGED INCANDESCENT			
Date of Test MAY 23, 1900			
Remarks			

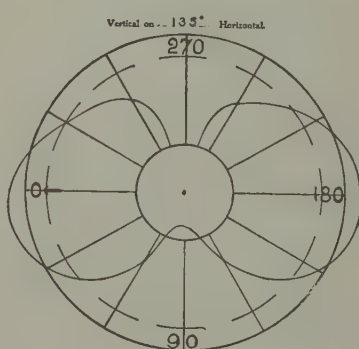
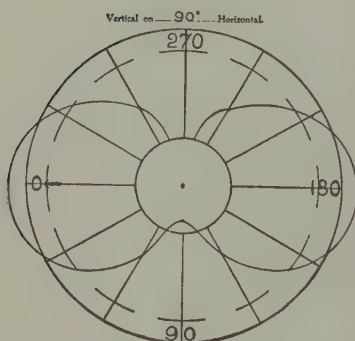
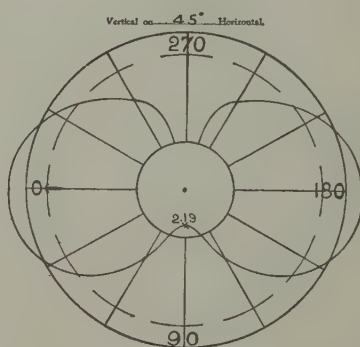
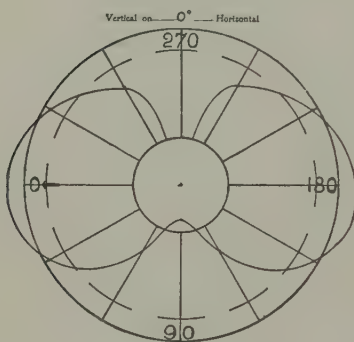
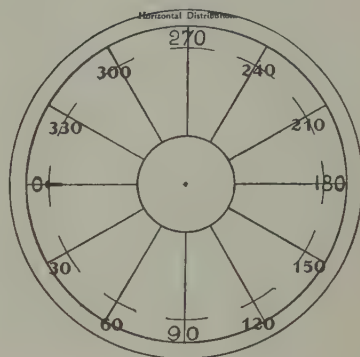


PLATE VII.

LAMP	
Number of Test	81
Mean Spherical Candle Power	112.8
Mean Horizontal Candle Power	140.7
Mean Standard Reading	13.34
Ratio Spherical to Standard	.846
Ratio Horizontal to Standard	1.05
Ratio Spherical to Horizontal	.803
Percent Absorption	16.2
Percent Light thrown below Equator	50.9
Percent Light thrown above Equator	49.1
Angle of Maximum Candle Power	0°
Cuts on Lamp	112.0
Watts in Lamp	49.6
Watts per Mean Spherical Candle Power	4.92
Watts per Mean Horizontal Candle Power	3.94
Circle Shows Rated Candle Power	
Circle Shows Mean Spherical Candle Power	
Circle Shows Mean Horizontal Candle Power	
Lamp Used	GE 112 v 16 CP
Shade Used	HOLOPHANE STALACTITE #3250
Standard Used	AGED INCANDESCENT
Date of Test	MAY 24, 1900.
Remarks	

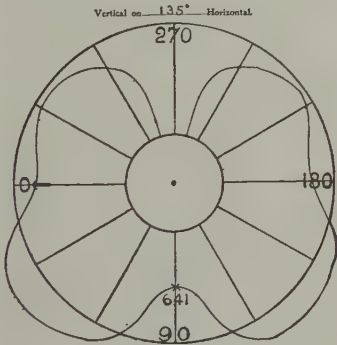
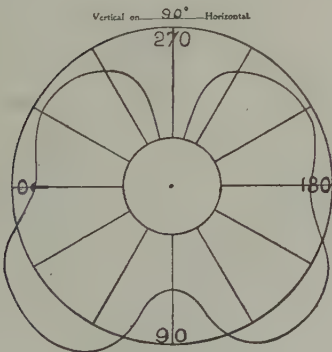
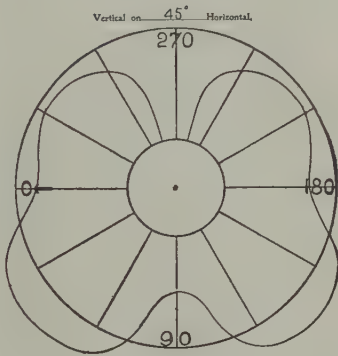
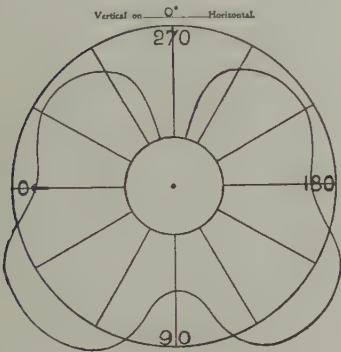
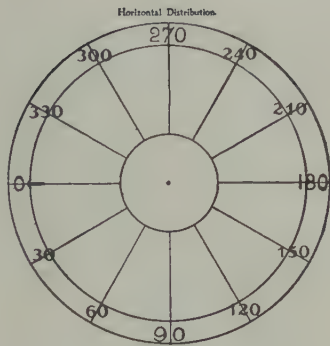


PLATE VIII.

LAMP		NAKED	SHADED
Number of Test	101		
Mean Spherical Candle Power		31.0	27.9
Mean Horizontal Candle Power		37.2	34.7
Mean Standard Reading		36.1	36.0
Ratio Spherical to Standard		86.6	79.6
Ratio Horizontal to Standard		1.03	99.2
Ratio Spherical to Horizontal		83.4	80.5
Percent Absorption		—	10.0
Percent Light thrown below Equator		50.2	62.6
Percent Light thrown above Equator		49.8	37.4
Angle of Maximum Candle Power		0°	-35°
Watts on Lamp		112.0	112.0
Temperature in Lamp		1.51	1.51
Watts in Lamp		169	169
Watts per Mean Spherical Candle Power		5.46	6.06
Watts per Mean Horizontal Candle Power		4.55	4.87
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used	GE 112 v. 50 c.p.		
Shade Used	HOLOPHANE STALACTITE '3250		
Standard Used	AGED INCANDESCENT		
Date of Test	MAY 24 1900		
Remarks	This test should be compared with #81 showing the effect of a wrong sized lamp in a Holophane shade.		

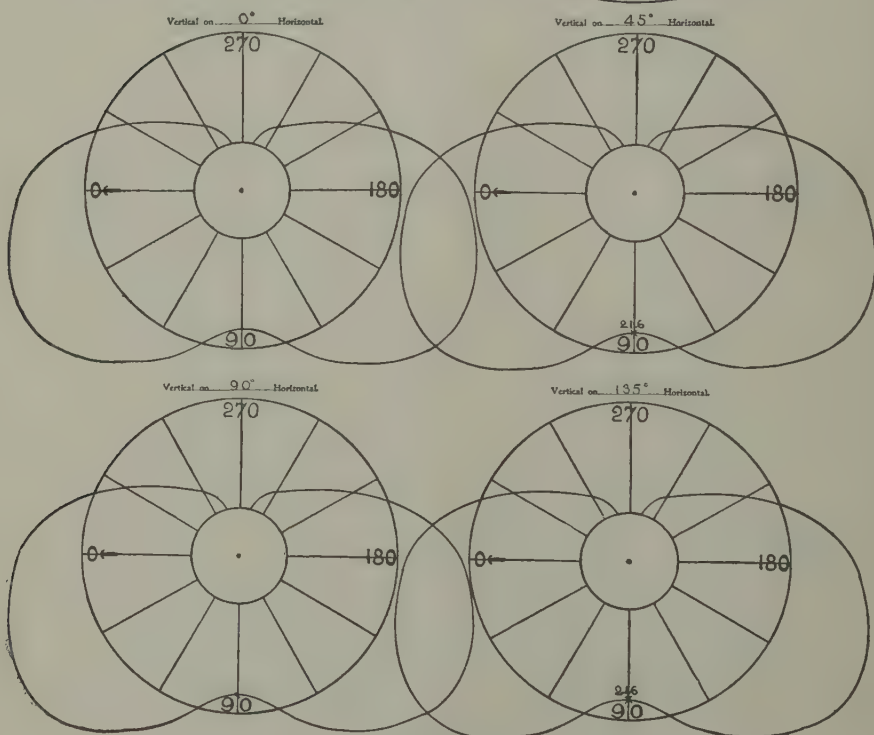
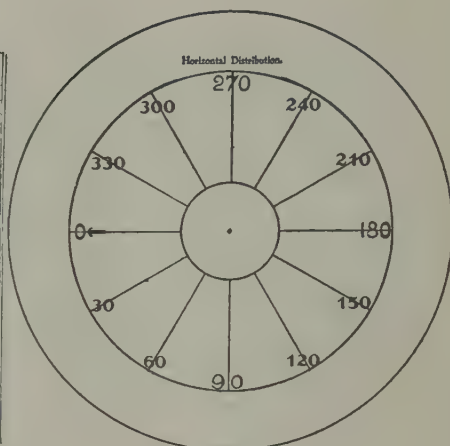


PLATE IX.

LAMP	
Number of Taps	111
Mean Spherical Candle Power	1122 8.63
Mean Spherical Candle Power	1437 3.26
Mean Spherical Candle Power	1324 2.23
Mean Spherical Candle Power	546 2.67
Mean Spherical Candle Power	103 2.92
Mean Spherical Candle Power	868 2.63
Mean Spherical Candle Power	23.8
Mean Spherical Candle Power	509 73
Mean Spherical Candle Power	43.1 27
Mean Spherical Candle Power	0° 90°
Mean Spherical Candle Power	112.0 112.5
Mean Spherical Candle Power	436 4.36
Mean Spherical Candle Power	536 5.36
Mean Spherical Candle Power	492 6.44
Mean Spherical Candle Power	394 17.4
Lamp Model	
GE 112-1850	
Bulb Type of OPAL GLASS BALL	
Bulb Type of AGED INCANDESCENT	
Base of Lamp	
E10	
Number of Taps in a Sphere per Revolution	
111	
The Upper Hemisphere of the Lamp Glass with a Star cut on it.	

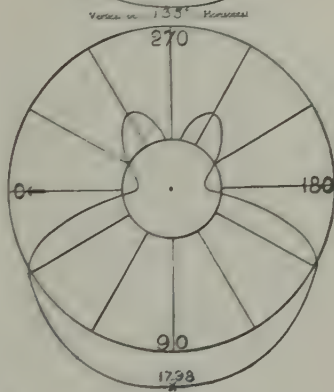
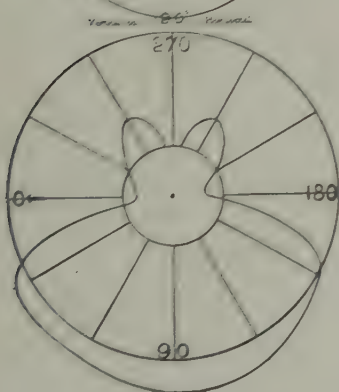
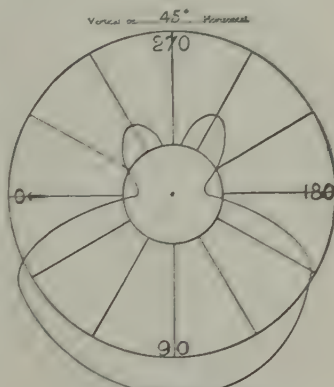
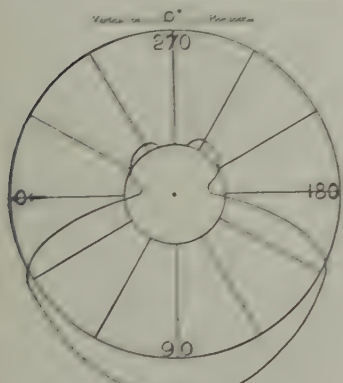
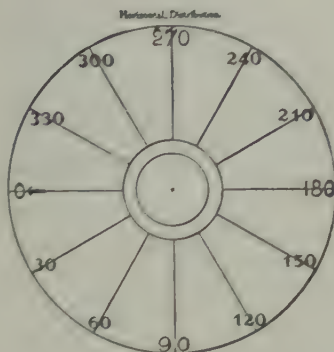
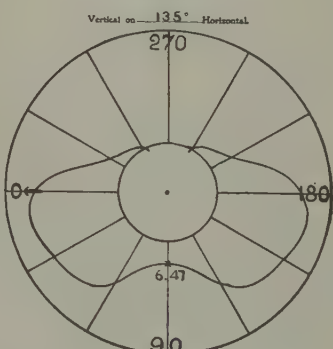
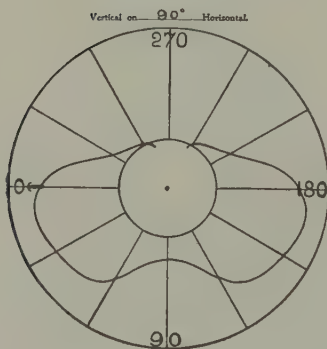
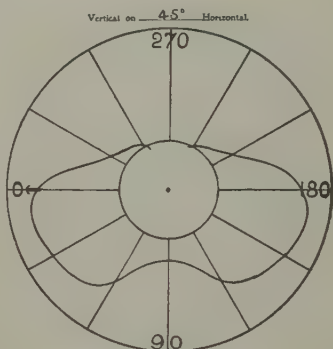
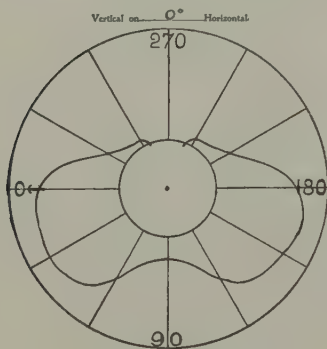
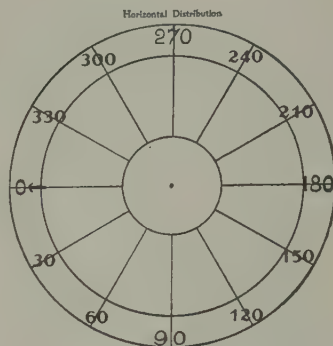


PLATE X.

LAMP		NAKED	SHADED
Number of Test	131		
Mean Spherical Candle Power		112.8	93.9
Mean Horizontal Candle Power		140.7	120.0
Mean Standard Reading		13.34	11.88
Ratio Spherical to Standard		.846	.790
Ratio Horizontal to Standard		1.05	1.01
Ratio Spherical to Horizontal		.803	.782
Percent Absorption		—	16.8
Percent Light thrown below Equator		50.9	60.2
Percent Light thrown above Equator		49.1	39.8
Angle of Maximum Candle Power		1.0°	-2.0°
Watts on Lamp		112.0	112.0
Amperes on Lamp		.496	.496
Watts in Lamp		55.6	55.6
Watts per Mean Spherical Candle Power		4.92	5.92
Watts per Mean Horizontal Candle Power		3.94	4.63
Circle Shows Rated Candle Power			
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used	GE 112 v 16 CP		
Globe Used	HOLOPHANE STALACTITE #3150		
Standard Used	AGED INCANDESCENT		
Date of Test	MAY 29, 1900		
Remarks	This stalactite is not identical with that used on Test 116. But is the old pattern both in shape and cutting, since replaced by the one used on Test 116.		



		LAMP	
		15NAKED	14SHADED
Number of Taps	14-15		
Mean Spherical Candle Power	270	24.60	19.10
Mean Horizontal Candle Power	180	23.90	7.85
Mean Standard Readings	100	30.35	9.90
Ratio Spherical to Standard	100	811	1.93
Ratio Horizontal to Standard	100	952	7.93
Ratio Spherical to Horizontal	100	852	2.43
Percent Absorption	100	53.2	100
Percent Light thrown below Equator	100	46.8	0
Percent Light thrown above Equator	100	0	90
Angle of Maximum Candle Power	100	112.0	112.0
Volts on Lamp	100	1.20	1.20
Amps on Lamp	100	134.4	134.4
Watts on Lamp	100	5.46	7.04
Watts per Mean Spherical Candle Power	100	4.65	17.2
		Circle Shows Mean Spherical Candle Power	
		Circle Shows Mean Horizontal Candle Power	
		Lamp Used AEG 112v 50cp SPHERICAL BULB	
		Shade Used BULB SILVERED ON UPPER HALF	
		Standard Used SPECIAL INCANDESCENT	
		Date of Test MAY 8, 1900	
		Remarks: The Lamp was tested with the silver mirror on, this was then washed off and the Lamp retested.	

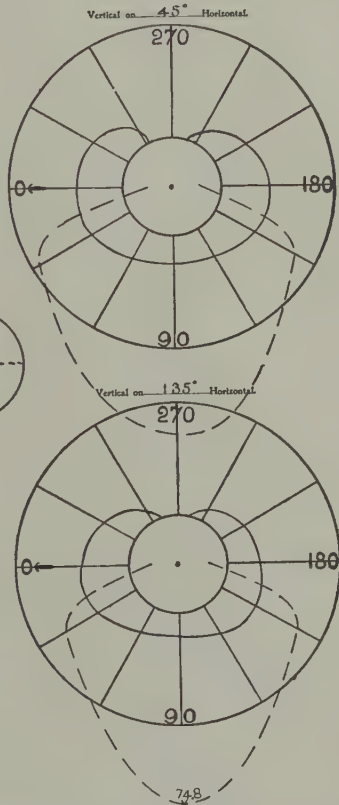
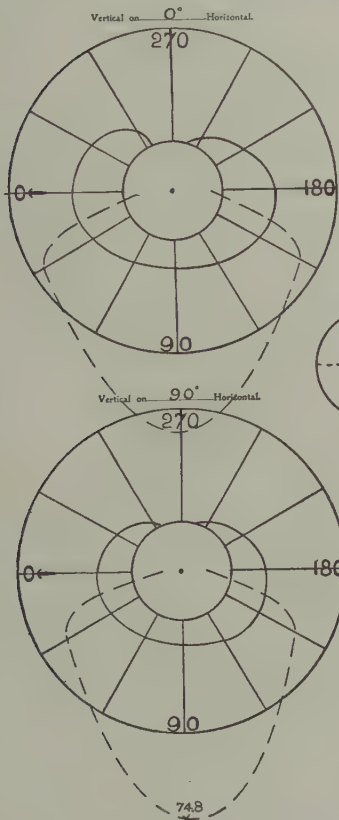
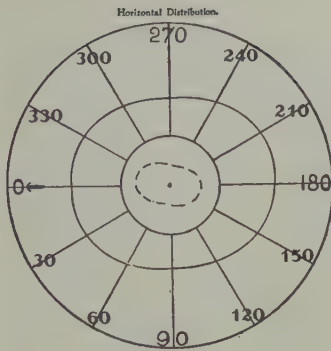


PLATE XII.—SPHERICAL BULB, BROKEN LINE, CURVE WITH SILVERING IN PLACE; SOLID LINE, WITH SILVERING REMOVED.

		LAMP	
		NAKED	SHADED
Number of Test	161		
Mean Spherical Candle Power		11.28	10.06
Mean Horizontal Candle Power		14.07	11.40
Mean Standard Readings		13.34	10.94
Ratio Spherical to Standard		.846	.920
Ratio Horizontal to Standard		1.05	1.04
Efficiency Spherical to Horizontal		.803	.884
Percent Absorption			10.8
Percent Light thrown below Equator		50.9	61.8
Percent Light thrown above Equator		49.1	38.6
Angle of Maximum Candle Power		0°	-40°
Volts on Lamp		112.0	112.0
Amperes in Lamp		.496	.496
Watts in Lamp		55.6	55.6
Watts per Mean Spherical Candle Power		4.92	5.52
Watts per Mean Horizontal Candle Power		3.94	4.87
Circle Shows Rated Candle Power			
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used, GE 112 v. 16 CP			
Shade Used, HOLOPHANE STALACTITE #3150			
Standard Used, AGED INCANDESCENT			
Date of Test, MAY 31, 1900			
Remarks			

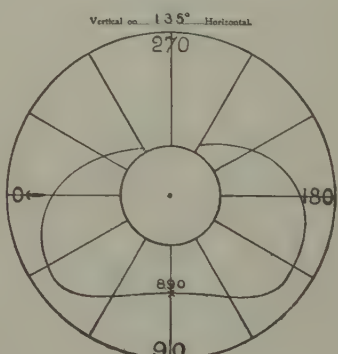
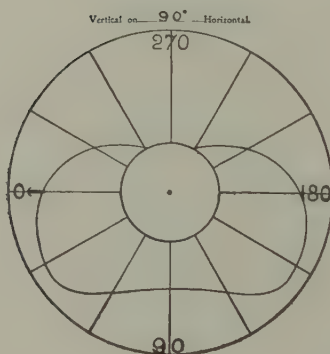
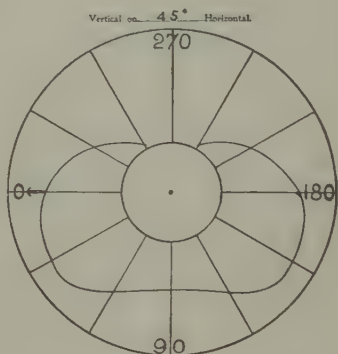
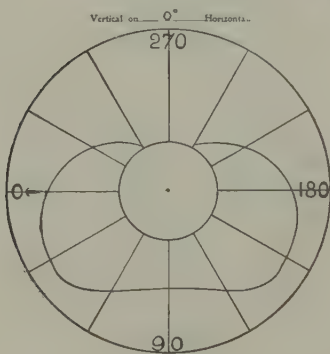
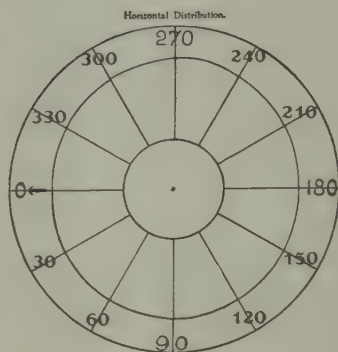


PLATE XIII.

LAMP		
	NAKED	SHADED
Number of Test <u>171</u>		
Mean Spherical Candle Power	11.28	9.92
Mean Horizontal Candle Power	14.07	10.48
Mean Standard Readings	13.24	10.46
Ratio Spherical to Standard	.846	.948
Ratio Horizontal to Standard	1.05	1.00
Ratio Spherical to Horizontal	.803	.946
Percent Absorption	—	12.1
Percent Light thrown below Equator	50.9	57.6
Percent Light thrown above Equator	49.1	42.4
Angle of Maximum Candle Power	0°	-35°
Volts on Lamp	112.0	112.0
Amperes on Lamp	.496	.497
Watts on Lamp	55.6	55.7
Watts per Mean Spherical Candle Power	4.92	5.61
Watts per Mean Horizontal Candle Power	3.94	5.31
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp used <u>GE 112v16cp</u>		
Shade used <u>HOLOPHANE SPHERE #3105</u>		
Standard used <u>A.E.D. INCANDESCENT</u>		
Date of Test <u>JUNE 2 1900</u>		
Remarks		

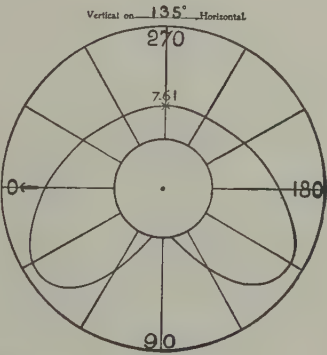
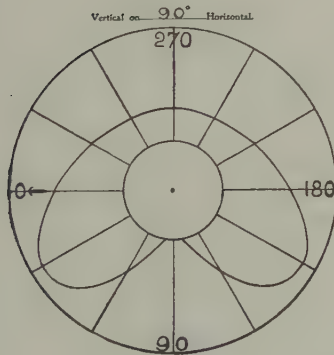
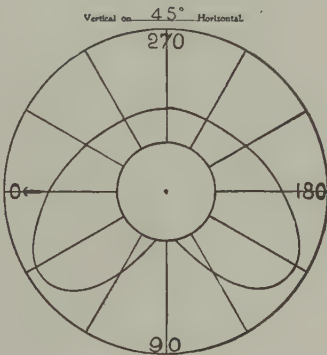
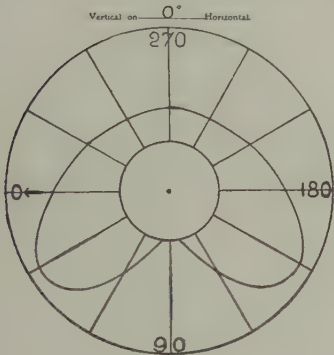


PLATE XIV.

Study of Certain Shades and Globes for Electric Lights. 211

LAMP		
	NAKED	SHADED
Number of Test 181		
Mean Spherical Candle Power	112.8	101.4
Mean Horizontal Candle Power	14.07	12.32
Mean Standard Readings	13.34	12.30
Ratio Spherical to Standard	.846	.825
Ratio Horizontal to Standard	1.05	1.00
Ratio Spherical to Horizontal	.803	.824
Percent Absorption	—	10.1
Percent Light thrown below Equator	50.9	59.3
Percent Light thrown above Equator	49.1	40.7
Angle of Maximum Candle Power	0°	40°
Watts on Lamp	112.0	112.0
Amperes on Lamp	.496	.497
Watts in Lamp	55.6	55.7
Watts per Mean Spherical Candle Power	4.92	5.50
Watts per Mean Horizontal Candle Power	3.94	4.52
Circle Shows Rated Candle Power		
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp Used	GE. 112 v. 15 CP	
Shade Used	HOLOPHANE TULIP #2251	
Standard Used	AGED INCANDESCENT	
Date of Test	JUNE 2, 1900	
Remarks		

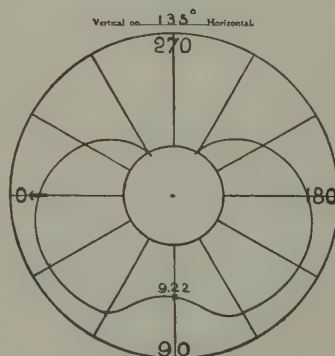
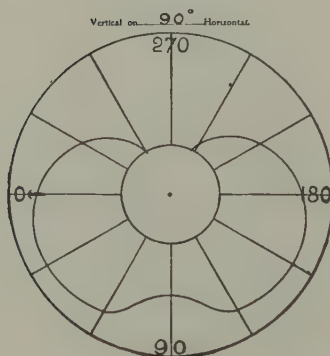
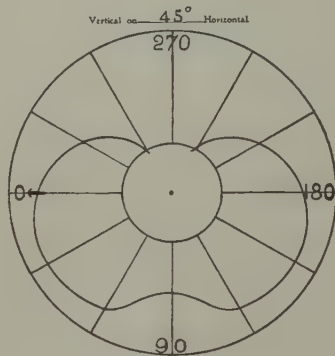
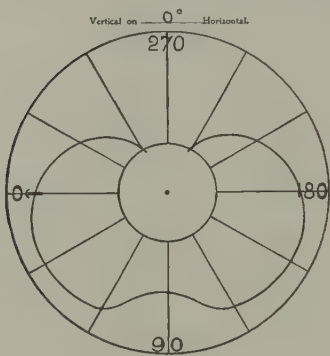
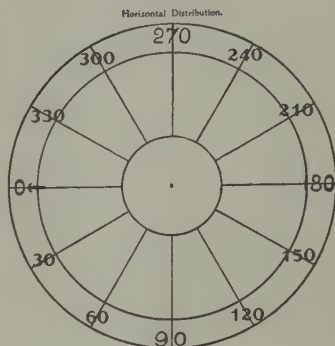


PLATE XV.

LAMP		
	NAKED	SHADED
Number of Test.	19.1	
Mean Spherical Candle Power	11.23	10.07
Mean Horizontal Candle Power	14.07	12.00
Mean Standard Reading	13.34	11.99
Ratio Spherical to Standard	.846	.841
Ratio Horizontal to Standard	11.03	1.00
Ratio Spherical to Horizontal	.803	.840
Percent Absorption		10.8
Percent Light thrown below Equator	50.9	69.9
Percent Light thrown above Equator	49.1	40.8
Angle of Maximum Candle Power	0°	-60°
Watts on Lamp	112.0	112.0
Amperes in Lamp	4.96	4.97
Watts in Lamp	55.6	55.7
Watts per Mean Spherical Candle Power	4.92	5.53
Watts per Mean Horizontal Candle Power	3.94	4.64
Circle Shows Rated Candle Power.		
Circle Shows Mean Spherical Candle Power.		
Circle Shows Mean Horizontal Candle Power.		
Lamp Used	GE 112V-15.0P	
Circle Used	HOLOPHANE TULIP "2250	
Standard Used	AGED INCANDESCENT	
Date of Test	JUNE 2, 1900	
Remarks		

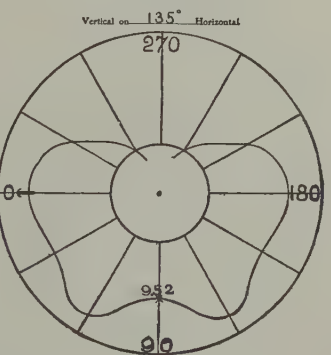
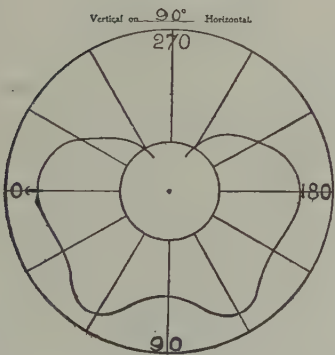
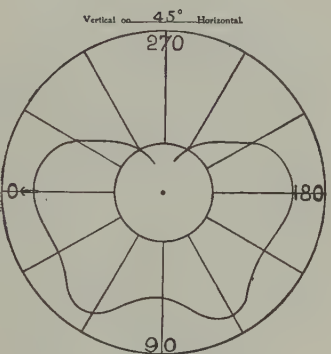
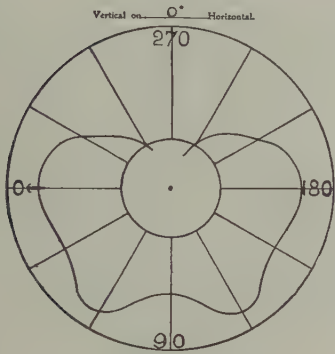
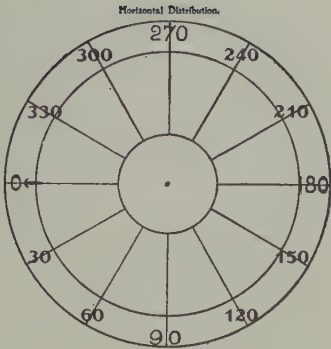


PLATE XVI.

TABLE		NAKED	SHADED
Number of Test	201		
Mean Spherical Candle Power		11.28	9.89
Mean Horizontal Candle Power		14.07	5.26
Mean Standard Reading		13.34	5.34
Ratio Spherical to Standard		.846	1.85
Ratio Horizontal to Standard		1.05	.985
Ratio Spherical to Horizontal		.803	1.88
Percent Absorption		—	12.4
Percent Light thrown below Equator		50.9	69.4
Percent Light thrown above Equator		49.1	30.6
Angle of Maximum Candle Power		0°	-40°
Watts on Lamp		112.0	112.0
Amps. in Lamp		.496	.497
Watts in Lamp		55.6	55.7
Watts per Mean Spherical Candle Power		4.92	5.63
Watts per Mean Horizontal Candle Power		3.94	10.6
Circle Shows Mean Candle Power			
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used	GE 112V-16CP		
Shade Used	DEEP CONE, ELUTED PORCELAIN		
Standard Used	AGED INCANDESCENT		
Date of Test	JUNE 6, 1900.		
Remarks			

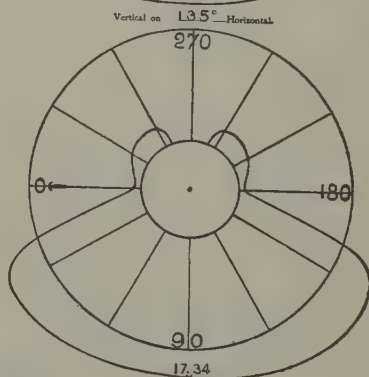
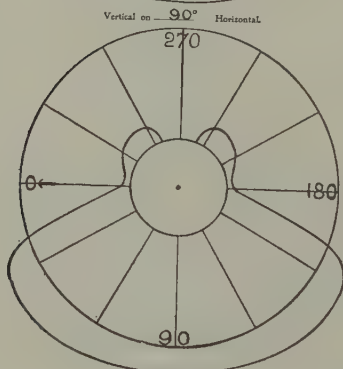
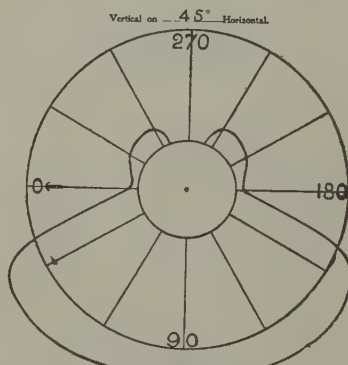
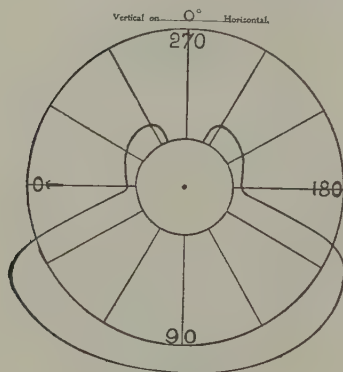
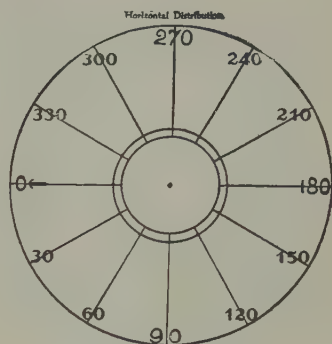


PLATE XVII.

LAMP		
	NAKED	SHADED
Number of Test <u>211</u>	1128	812
Mean Spherical Candle Power	14.07	0.0
Mean Horizontal Candle Power	13.32	0.0
Mean Standard Reading	846	—
Ratio Spherical to Standard	1.05	—
Ratio Horizontal to Standard	803	—
Ratio Spherical to Horizontal	—	28.1
Percent Absorption	50.9	100
Percent Light thrown above Equator	49.1	0.0
Percent Light thrown below Equator	0°	-90°
Angle of Maximum Candle Power	112.0	112.0
Volts on Lamp	496	497
Amps on Lamp	55.6	55.7
Watts on Lamp	492	6.66
Watts per Mean Spherical Candle Power	3.94	—
Watts per Mean Horizontal Candle Power	—	—
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp Used: <u>GE 112 v 16 cp</u>		
Shade Used: <u>ENAMELLED TIN DEEP CONE 8°</u>		
Standard Used: <u>AGED INCANDESCENT</u>		
Date of Test: <u>JUNE 7 1900</u>		
Remarks		

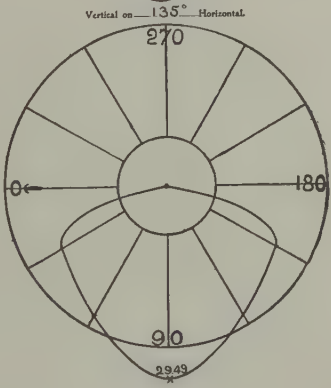
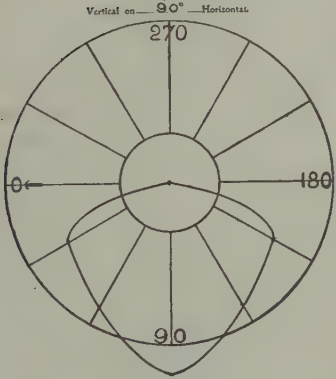
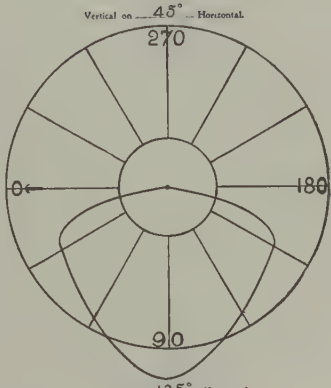
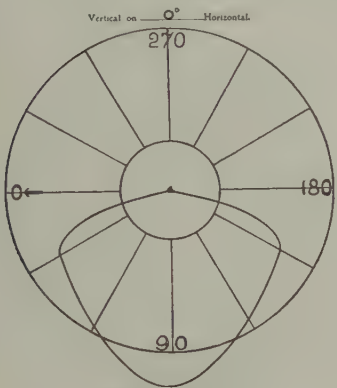
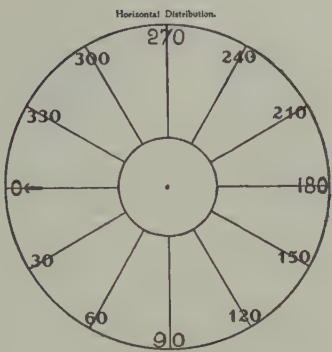


PLATE XVIII.

		LAMP	
		NAKED	SHADED
Number of Test	221		
Mean Spherical Candle Power		1128	984
Mean Horizontal Candle Power		1407	1394
Mean Standard Reading		13.34	13.96
Ratio Spherical to Standard		846	704
Ratio Horizontal to Standard		105	999
Ratio Spherical to Horizontal		803	706
Percent Absorption		128	
Percent Light thrown below Equator		509	740
Percent Light thrown above Equator		491	260
Angle of Maximum Candle Power		0°	-30°
Watts on Lamp		112.0	112.0
Watts in Lamp		496	497
Watts per Mean Spherical Candle Power		5.56	5.57
Watts per Mean Horizontal Candle Power		4.92	5.66
Circle Shows Mean Spherical Candle Power			
Circle Shows Mean Horizontal Candle Power			
Lamp Used	GE 112V 16CP		
Shade Used	FLAT CONE FLUTED PORCELAIN 6"		
Standard Used	AGED INCANDESCENT		
Date of Test	JUNE 7 1900		
Remarks			

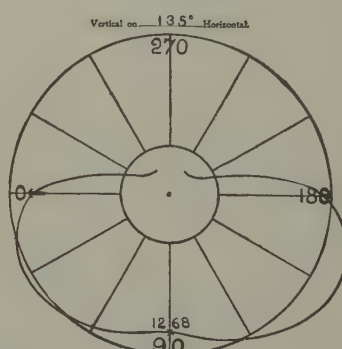
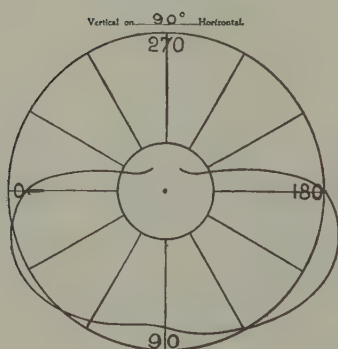
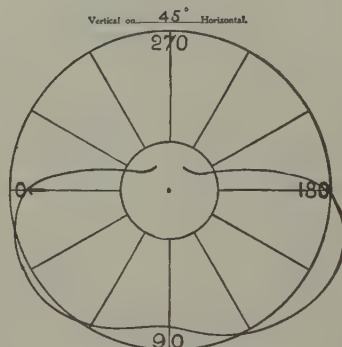
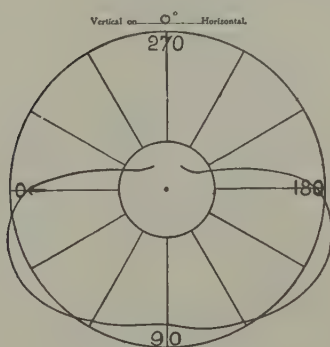
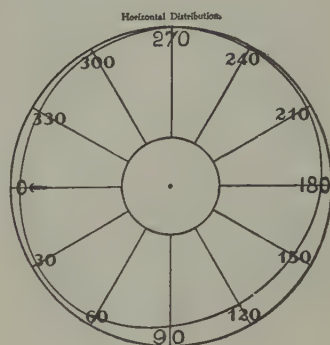


PLATE XIX.

TABLE		
Number of Test	231	
Mean Spherical Candle Power	13.50	10.20
Mean Horizontal Candle Power	16.80	13.08
Mean Standard Readings	16.83	12.92
Ratio Spherical to Standard	802	790
Ratio Horizontal to Standard	398	101
Ratio Spherical to Horizontal	804	780
Percent Absorption	—	24.4
Percent Light thrown below Equator	50.4	53.6
Percent Light thrown above Equator	49.6	46.4
Angle of Maximum Candle Power	0°	0°
Volts on Lamp	112.0	112.0
Amps in Lamp	501	500
Watts in Lamp	561	560
Watts per Mean Spherical Candle Power	415	54.9
Watts per Mean Horizontal Candle Power	334	4.48
Circle Shows Rated Candle Power.		
Circle Shows Mean Spherical Candle Power.		
Circle Shows Mean Horizontal Candle Power.		
Lamp Used	B-M 112V 16CP	
Shade Used	GROUND GLASS BALL 6 INCH	
Standard Used	AGED INCANDESCENT	
File of Test	JUNE 6, 1900	
Remarks		

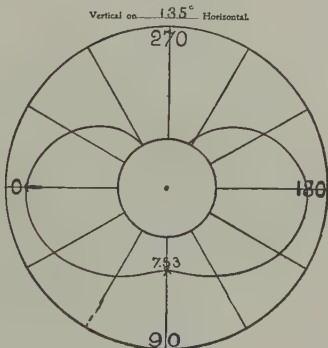
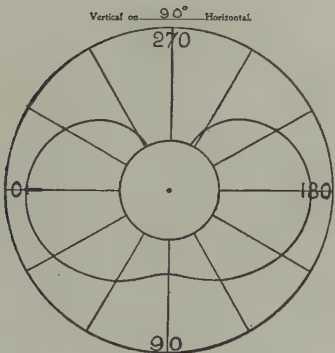
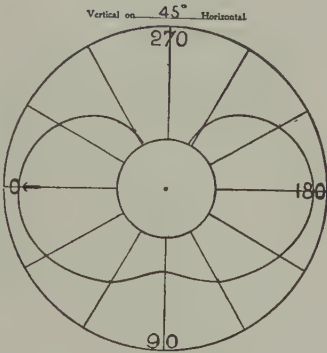
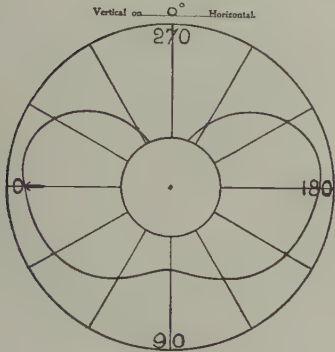
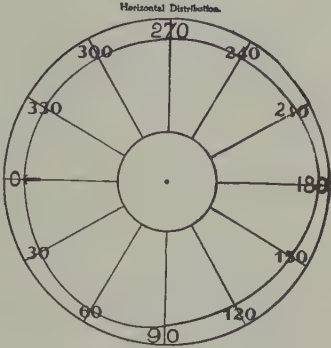


PLATE XX.

Number of Test	T.A.M.P.	
	NAKED	SHADED
Mean Spherical Candle Power	13.50	10.73
Mean Horizontal Candle Power	16.80	15.85
Mean Standard Reading	16.83	15.23
Ratio Spherical to Standard	.808	.704
Ratio Horizontal to Standard	.998	1.03
Ratio Spherical to Horizontal	.804	.686
Percent Absorption	—	20.7
Power Light thrown below Equator	50.4	54.0
Power Light thrown above Equator	49.6	46.0
Angle of Maximum Candle Power	0°	0°
Watts on Lamp	112.0	112.0
Response in Lamp	56.1	56.1
Watts on Lamp	56.1	56.1
Watts per Mean Spherical Candle Power	4.15	5.22
Watts per Mean Horizontal Candle Power	3.34	3.57
Circle Shows Band Candle Power		
Circle Shows Mean Spherical Candle Power		
Circle Shows Mean Horizontal Candle Power		
Lamp Used	B.M. 112 V. 16 CP	
Shade Used	PRISMATIC GLASS BALL 6 INCH	
Standard Used	AGED INCANDESCENT	
Date of Test	JUNE 7, 1900	
Remarks		

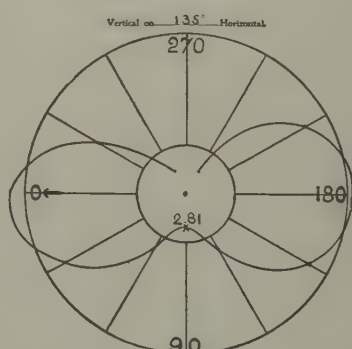
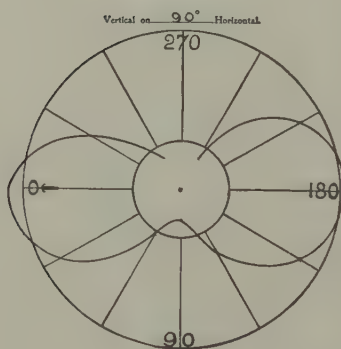
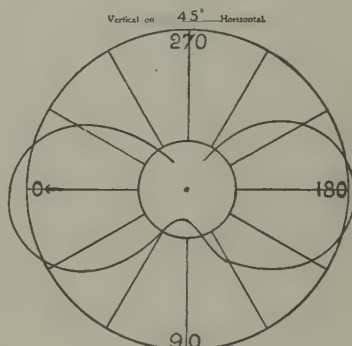
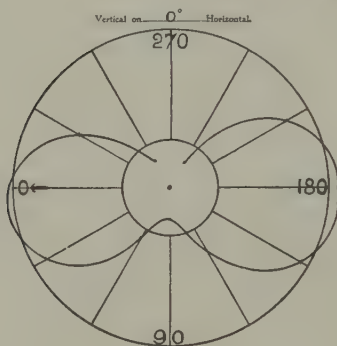
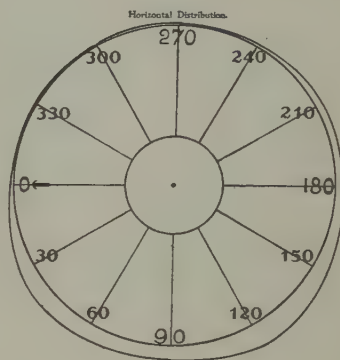


PLATE XXI.

LAMP		
	NAKED	SHADED
Number of Test 251		
Mean Spherical Candle Power	13.50	9.15
Mean Horizontal Candle Power	16.80	10.05
Mean Standard Headings	16.83	10.03
Ratio Spherical to Standard	.802	.912
Ratio Horizontal to Standard	.998	1.00
Ratio Spherical to Horizontal	.804	.912
Percent Absorption	—	32.2
Percent Light above Horizontal Equator	50.4	50.0
Percent Light above above Equator	49.6	50.0
Angle of Max mean Candle Power	0°	0°
Watts on Lamp	112.0	112.0
Amps in Lamp	.501	.501
Watts in Lamp	56.1	56.1
Watts per Mean Spherical Candle Power	4.16	6.13
Watts per Mean Horizontal Candle Power	3.34	5.58
Circle Shows Rated Candle Power.		
Circle Shows Mean Spherical Candle Power.		
Circle Shows Mean Horizontal Candle Power.		
Lamp Used	B.M. 112 v 16 CP.	
Shade Used	.6 INCH OPAL BALL	
Standard Used	AGED INCANDESCENT	
Date of Test	JUNE 7 1900	
Remarks		

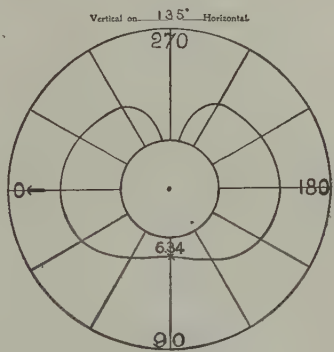
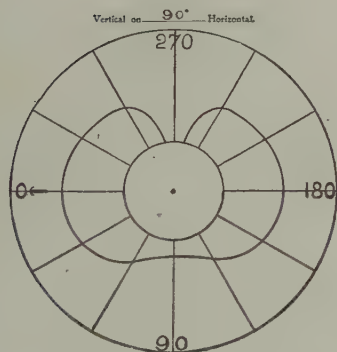
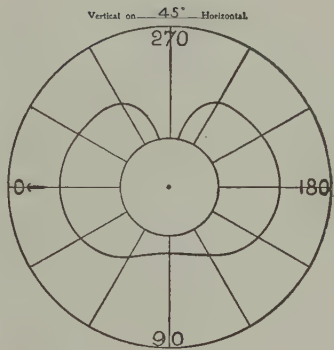
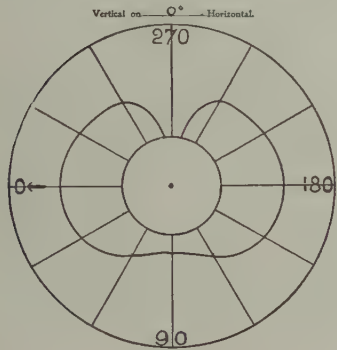
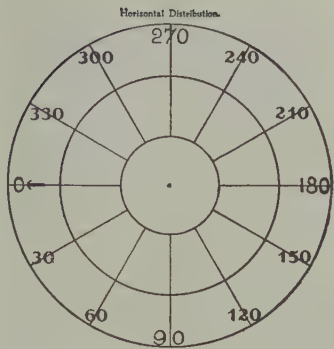
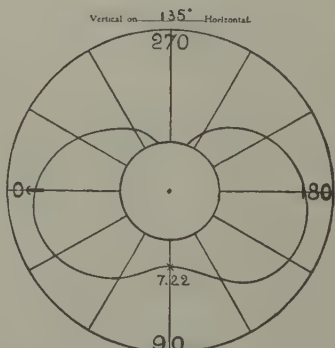
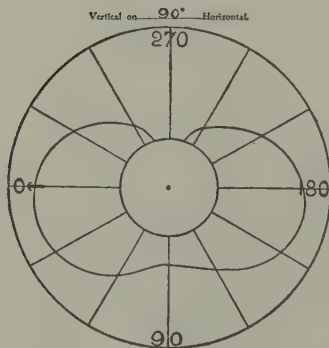
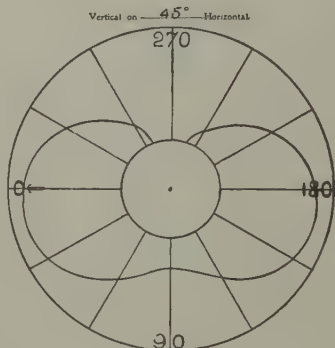
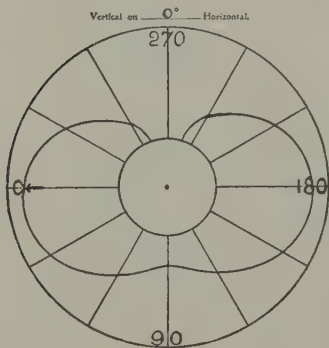
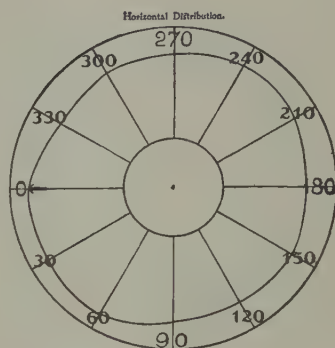


PLATE XXII.

LAMP		
	NAKED	SHADED
Number of Tubs <u>261</u>		
Mean Spherical Candle Power	13.50	10.38
Mean Horizontal Candle Power	16.80	12.50
Mean Standard Readings	16.83	13.20
Ratio Spherical to Standard	.802	.787
Ratio Horizontal to Standard	.996	.948
Ratio Spherical to Horizontal	.804	.831
Percent Absorption	—	23.0
Percent Light thrown below Equator	50.4	54.5
Percent Light thrown above Equator	49.6	45.5
Angle of Maximum Candle Power	0°	-10°
Watts on Lamp	112.0	112.0
Amperes in Lamp	5.01	5.02
Volts in Lamp	56.1	56.2
Watts per Mean Spherical Candle Power	4.15	5.42
Watts per Mean Horizontal Candle Power	3.34	4.50
Circle Shows Read Candle Power.		
Circle Shows Mean Spherical Candle Power.		
Circle Shows Mean Horizontal Candle Power.		
Lamp Used	B-M 112 v. 16 c.p.	
Globe Used	OPALINE BALL SPIRAL FLUTINGS 6	
Standard Used	AGED INCANDESCENT	
Date of Test	JUNE 8, 1900	
Remarks		



The absorption factors range from a minimum of 10 per cent. to a maximum of 33.5 per cent., in the cases of the large Holophane Stalactite (using the 50 candle-power lamp) and the McCreary Shade, respectively. The watts per mean spherical candle-power vary from a minimum of 5.22 to a maximum of 7.41 in the cases of the Prismatic Glass Ball and the McCreary Shade respectively.

The watts per maximum candle-power vary from a minimum of 1.30 to a maximum of 5.64 in the cases of the McCreary Shade and the Stalactite Prism respectively.

It is, however, manifestly unfair to make a direct comparison between a shade which, like the silvered minor A. E. G. lamp, aims simply to concentrate the light downward without diffusion, and one which, like the Opal Ball, aims simply to diffuse the light without changing its distribution materially; while, again, both these types should be separated from such shades as the Holophanes, which aim not only at redistribution, but at diffusion, and, moreover, at such thorough softening of the light as to render it possible to see objects comfortably, even when the light is directly in the field of view (as is perfectly possible with a 12-inch sphere containing a 100 candle-power light). Indeed, in one place recently fitted with these shades, there was a 16-inch sphere containing a 150 candle-power lamp surrounded by a circle of eight 8-inch spheres, each containing a 32 candle-power lamp, giving a maximum of 360 candle-power, allowing for absorption, concentrated in a space of about fifty square feet, and the lights nearly in the same plane. It was here found perfectly possible to view with comfort the detail of ornament directly behind this cluster.

The Holophanes, therefore, set themselves a more difficult problem than the great majority of shades tested, and one would hardly expect as great efficiency from them as from a pattern aiming at a less exalted mark. This, however, turns out contrary to expectation.

Another point to be considered is brought out by these tests as follows: If we take the Holophane, Class A, No. 3,354, and test it with a 32 candle lamp, we shall have an absorption of 14.6 per cent., while, if we test it with a 16 candle lamp we get an absorption of 12.2 per cent. Again, take the larger stalactite, No. 3,250. Testing with a 16 candle lamp at 112 volts, we find an absorption of 16.2 per cent. If we use this same lamp, and run it at 140 volts, thus getting a candle-power of (as it turned out) 37, we find the absorption has risen to 17.5 per cent., the distribution not being greatly changed.

This, I think, is because of the higher refrangibility of the rays given out. But if we get this same candle-power by using a larger lamp, as is shown in column 4 A of the table, we get an absorption of but 10 per cent. Accordingly, as I have found this rule to hold in other cases as well as those here mentioned, it seems clear that for each size of Holophane shade there is a particular sized lamp which will turn out to be best suited to that shade.

If, then, we tabulate the tests upon the Holophane type of shades, we shall have the following table, giving as a mean percentage of absorption 13.2 per cent. :

	Number of shade.	Per cent. absorption.	Effi. in terms of watts per mean sph. c. p.
1	3,551.	13.8%	86.3
2	3,354 (16 candle-power.)	12.2%	89.3
3	3,354 (32 candle-power.)	14.6%	85.6
4	3,250 (16 candle-power.)	16.1%	84.1
5	3,250 (same lamp, run 30 volts high.)	17.5%	77.0
6	3,250 (50 candle-power.)	10.0%	90.2
7	3,150 (old style.)	16.8%	83.4
8	3,150 (new style.)	10.8%	89.4
9	3,105.	12.1%	87.8
10	2,250.	10.8%	89.4
11	2,251.	10.1%	89.3

The above value, however, includes two items which could be with perfect justice discarded, namely, Nos. 5 and 7, the former because no one would ever dream of running a lamp 30 volts high, and the latter because it represents an obsolete form which was tested only as a matter of historical interest. Discarding, then, these two values, the mean result remaining is 12.3 per cent. This, again, might with good show of reason be reduced by further omitting Nos. 3 and 4, since, as we have seen, if this type of shade is used under strictly the best conditions, the size of shade and lamp will be mutually adjusted. If this modification be made, we reach a final value of 11.4 per cent. as the absorption. As, however, it is not probable that in

many cases such an amount of care would be used, we will take both values into consideration. We shall find that, except for the satisfaction of being able to claim an additional 0.9 per cent. for this type of shade, nothing is altered. The only shade which appears with a less absorption factor is the "m" Prismatic Tulip, with a value of 10.1 per cent. The two fluted-Porcelain Cones are the only shades which approach the above values, having one an absorption of 12.4 per cent., and the other an absorption of 12.8 per cent. These, however, are both simply reflectors, and make no claim to diffusion or softening of glare, while the "m" Prismatic Tulip is also in no sense a substitute for the Holophane, and is hardly more than a clear glass shade with ornamental cutting. Aside from these three, no other shade comes within 10 per cent. of the Holophanes, the nearest approach being that of the Prismatic Ball, with a value of 20.7 per cent. The McCreary shade stands at the other end of the list, its absorption being 33.5 per cent.; it has close competitors, however, in the Stalactite Prism, the Opal Ball, and the Tin Cone, with absorptions of 30.8 per cent., 32.2 per cent., and 28.1 per cent. respectively.

We may compare efficiencies in the line of watts per mean spherical candle-power, but since the various test lamps used do not have the same values for this quantity, we cannot compare the shades directly. We may, however, determine for each shade the value of

$$\frac{\text{Watts per mean spherical candle power (unshaded lamp)}}{\text{Watts per mean spherical candle power (shaded lamp)}}$$

when the most efficient shade will, of course, be that in which this quantity most nearly approaches unity.

Applying this criterion, and figuring the Holophanes as before, we get values 86.6 per cent., 87.9 per cent., and 88.8 per cent. respectively. Again, agreeing that the first value is not properly to be used, we find that it makes no difference which of the other two we see fit to use, which, of course, is to be expected, as this is only another way of expressing the former results. The "m" Prismatic Tulip has a value of 89.3, and the two Porcelain Cones of 87.8 per cent. and 87.0 per cent. respectively.

If we consider further the watts per maximum candle-power thrown in any direction, we find, of course, that the pure reflectors take first rank. The McCreary shade leads on the face of things, followed rather closely by the A. E. G. silvered lamp, and at a somewhat greater distance by the Enamel Tin Cone. I question, however,

whether this is correct, since the A. E. G. lamp was not really new, but had been burned, off and on, for some time, probably for a hundred or more hours, so that, although it furnished legitimate data for determining the effect of silvering a naked lamp of the same type, it is not probably correct to compare it with the other shades fitted with newer and more carefully kept lamps.

Thus far, nothing has been said upon the very important subject of illumination produced upon surfaces such as the floor, drawing-tables, etc., or of the general distribution of light throughout the room. Neither has the quality of the illumination, nor its effect upon the worker or occupant of the room been considered. These matters are reserved for further investigation, and it is hoped will form a second part of the present article.

From the results obtained so far in the investigation, it is my opinion that the Holophane type of shade is very greatly superior in general results to any other investigated.

ROGERS LABORATORY OF PHYSICS,
June, 1900.

32.N.91.

A study of certain shades and g1900

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